BLUE PRINT READING

or

Interpreting Working Drawings

E. M. WYATT

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PREFACE

This book is the result of several years teaching of blueprint reading in night schools and several years teaching of drafting preceding it. The material was used for three years in blueprint and mimeographed form. In this form it was thoroughly tried out. In preparing it for book form the drawings have been carefully redrawn and the text improved upon as experience suggested to be desirable. Essentially it is, however, a tried text, one that has been used to teach the reading of drawings to one class of mixed trades, one class of ship carpenters, two classes of house carpenters, and one class of machinists.

It has been designed to suit as wide a range of trades as possible. Usually each new principle is illustrated by both a machine and an architectural example.

In recognition of the principle that we learn by doing a number of drawings are included to give practise in reading. At the end of each chapter a number of questions are placed, a few for the purpose of review, but more to stimulate the study of the drawings.

The study of mechanical drawing has long been recognized as a sure method of learning to read drawings. The Author knows it to be effective but round about, long and tedious. The Author finds shop sketching just as effective and much quicker. It is essential that students have some method of expression of the principles discussed in the text and shop sketching provides this admirably.

When time permits the book can well be supplemented with the study of many blueprints supplied by the teacher or the students and much more sketching than called for herein can also be effectively required.

The Author believes the book to be well suited to individual study aside from its use as a class text. When so used he urges that the shop sketching be not neglected, and that the student seek criticism of his drawings by some draftsman.

Most of the drawings used herein have been designed especially to illustrate the text. The drawings "For 8″ Bench Grinder," however, are taken from the excellent little books "First Year Lathe Work" and "How to Run a Lathe" published by the South Bend Lathe Works. The Author gratefully acknowledges the courteous privilege granted him to use them in this work.

THE AUTHOR.

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INTRODUCTION

Mechanical drawing is a universal language understood by the artisans of all nations. The drawings made by a skillful French draftsman are just as readable to an American draftsman as those made by his fellow draftsmen though he may know no tongue but his native one. It is a language with rules of grammar just as any other language, and a draftsman is a good or poor draftsman very largely as he observes or violates these rules.

It is a valuable business asset to many of us to be able to understand and speak French, Spanish or some other language than our own. It may be of no value to us to be fluent writers or speakers in the tongue. Just so, a great many men in this great industrial age are finding it necessary to understand the great universal language of mechanical drawing. It may not be necessary for them to have a thoro by-rule-of-grammar knowledge but simply a working knowledge that permits them to understand a draftsman and perhaps on occasion to roughly "talk-pencil" themselves. Those who need an expert knowledge of drawing must secure it thru taking a thoro course in mechanical drawing. For those who by means of reading wish to acquire easily a working knowledge on this subject, this course has been prepared.

The course has been prepared with the idea of giving an understanding of the fundamental underlying principles of mechanical drawing, a knowledge of drafting conventions, practice in the interpreting of drawings, and some practice in expressing one's own ideas by "shop sketching."

Mechanical drawing is used principally by two great groups of artisans—those engaged in the building trades, and those in the machinist or allied trades. For this reason the drawings in this course are as evenly as practicable divided between those used in these two great industrial groups.

The work in "shop sketching" is put in to fill the need for some form of expression on the student's part of the information imparted in the instructions. It is

a well understood and sound principle of teaching that we do not really know a thing until we can give some expression to that information, or in other words make some use of it. Besides, the ability to "talk pencil" is a very valuable acquisition to one who may be called upon to explain the meaning of a drawing or give constructive directions to others.

Students should provide themselves with a good medium or soft lead pencil, a draftsman's "B" pencil is a very suitable one, an eraser, a pad of one-eighth inch sectional ruled paper, and a pad of cheap drawing paper. It is desirable that these pads be about the size of a sheet of ordinary typewriting paper, 8½ inches by 11 inches.

II. KINDS OF DRAWINGS

Drawings are of various kinds. Plate I shows several articles represented by the more common kinds of drawings. These are Perspective, Isometric, Cabinet, Oblique and Orthographic. The perspective is the kind of drawings used for ordinary illustration work. It may be a simple outline drawing as these in the first column of Plate I, or it may be an actual photographic reproduction with an infinite detail and blending of light and shade. It is a drawing of an object as it appears to the eye of the draftsman. On first thought, this would seem to be the ideal form of drawing. It serves to show how an object looks, but it is dedefective from the standpoint of showing how an article is to be constructed.

In a perspective drawing the farther from the viewer a part is, the smaller it is on the drawing. The cube shown in Plate I illustrates this well. Tho it represents a one-half inch cube all edges of which are one-half inch long, there is but one line on the perspective drawing of it which measures a full half inch in length. This characteristic of perspective drawings makes them of little value as drawings for a workman to work from, as there is no way he can scale or measure the drawing for sizes.

Isometric drawings are often called false perspective, or shop perspective drawings as they are a form of imitation perspective. Isometric drawings always represent the object with three surfaces, usually the top and two adjacent sides, all inclined at equal angles with the eye, or—what amounts to the same thing—at an apparent equal angle with the surface of the paper on which the drawing is drawn. The lines of an isometric drawing are not made foreshortened by the distances as they are in a perspective drawing, so that they may be readily scaled by a workman working from such a drawing. Such drawings are much more easily made than perspective drawings and have the advantage of giving a fair pictorial representation of an object and at the same time are drawings from which a workman can work.

It will be observed that isometric drawings give the distorted appearance of representing the object as too large at the rear. This is because the eye expects things on a drawing to appear as in nature, smaller the farther they are away, or technically, foreshortened. This distortion is very apparent in the Box and Cylinder represented in isometric on Plate I because these are long objects.

Cabinet and Oblique drawings are very similar. Both represent one face of the object as being apparently parallel with the surface of the paper. Lines which, on the object are perpendicular (or square)

with this surface are represented as extending up and to the right. In cabinet drawings these lines are at an angle of forty-five degrees (45°) with the horizontal and are drawn only half their true length (foreshortened.) In oblique drawings these lines are drawn at an angle of thirty degrees (30°) with the horizontal and are drawn their full length—or in other words are not foreshortened.

Cabinet drawings are nearly as satisfactory as isometric drawings from a pictorial standpoint, but are somewhat unsatisfactory from a workman's standpoint due to the foreshortening of the lines drawn at forty-five degrees (45°). The oblique drawings are more satisfactory from a workman's standpoint as all lines are drawn the full length. They are the easiest drawings to make of simple objects, but they make a very distorted pictorial representation of the object.

Orthographic drawings have very little pictorial value but they are so superior to all other forms of drawings from the standpoints of the workman and the draftsman that probably over 95% of all working drawings are made in this form. Orthographic drawings always have two distinct parts, sometimes three or four. One of these parts is usually called the plan or top view and represents the object as it appears from directly overhead. Another is known as the Elevation or Front View and represents the object as it appears directly from the front. The Cube and Box in Plate I are represented by these two views. On the drawings of the Cylinder and the Hardie, however, no plans or top views are used but side views or side elevations supplements the front views or elevations in giving information which is not given in those views. Among the more advanced plates in the book you will find examples of drawings where it takes three and perhaps even four views to properly represent the details of an object.

QUESTIONS AND PROBLEMS.

1. What are the five kinds of drawing in ordinary use?
2. What kind of drawing is represented by the ordinary newspaper cut?
3. Why is such a drawing a poor one for a workman to work from? If this is not clear to you try taking some pictures from a furniture advertisement and with the information that chair seats are 18 inches high and table tops 32 inches high, try by scaling to establish other dimensions on a chair or table.
4. How many pieces of wood are required to make the box as shown in Plate I?
5. With a rule determine what are the overall dimensions of the Box assuming it to be drawn full size?
6. How deep is the hole in the Cylinder?
7. How long is the shank of the Hardie?
8. Which is the only drawing from which you can accurately get the answer to question 7, and why?

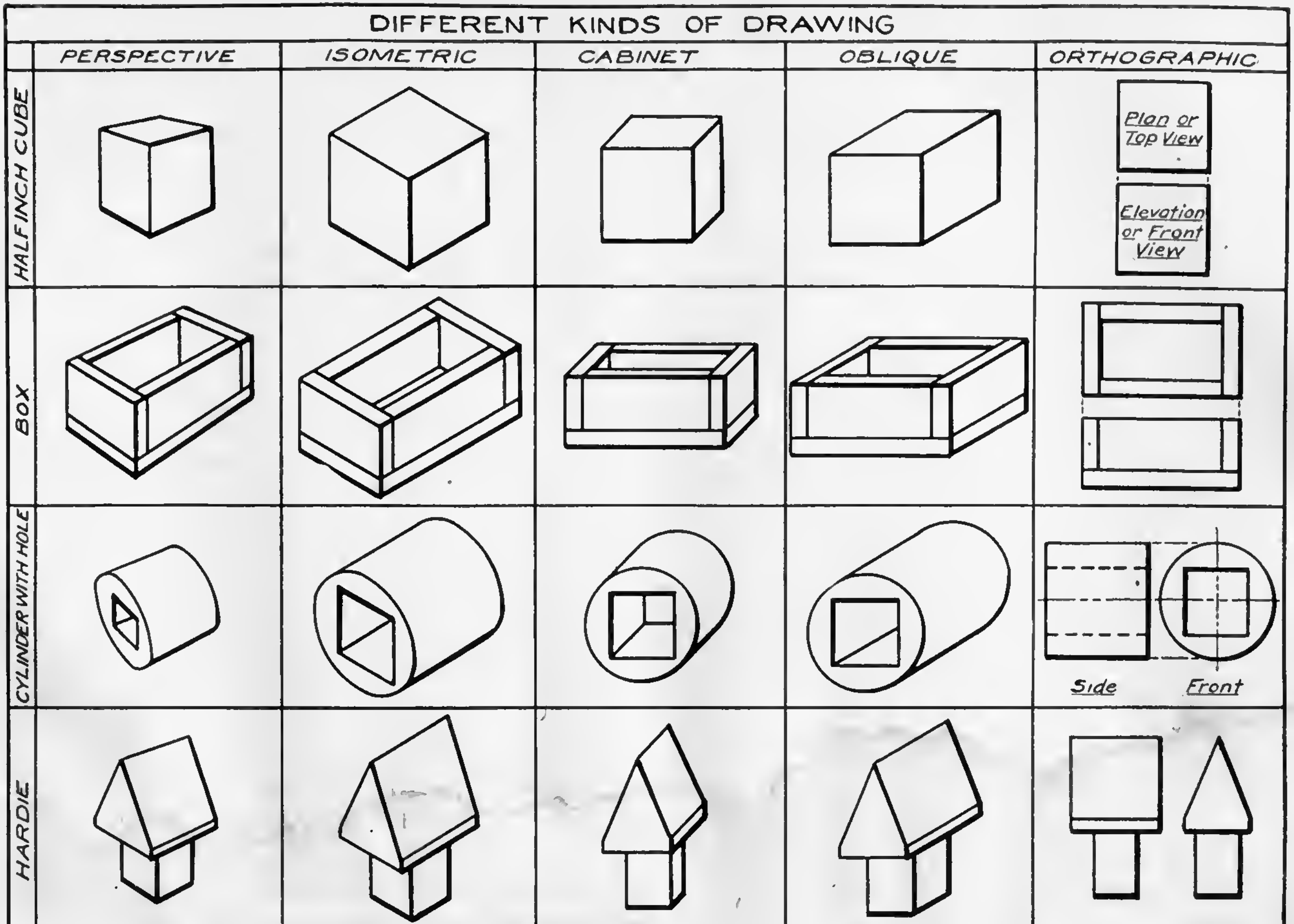

DIFFERENT KINDS OF DRAWING
PERSPECTIVE
ISOMETRIC
CABINET
OBLIQUE
ORTHOGRAPHIC
HALF INCH CUBE
BOX
CYLINDER WITH HOLE
HARDIE
Plan or Top View
Elevation or Front View
Side
Front

Plate I

III. THE THEORY OF ORTHOGRAPHIC PROJECTION

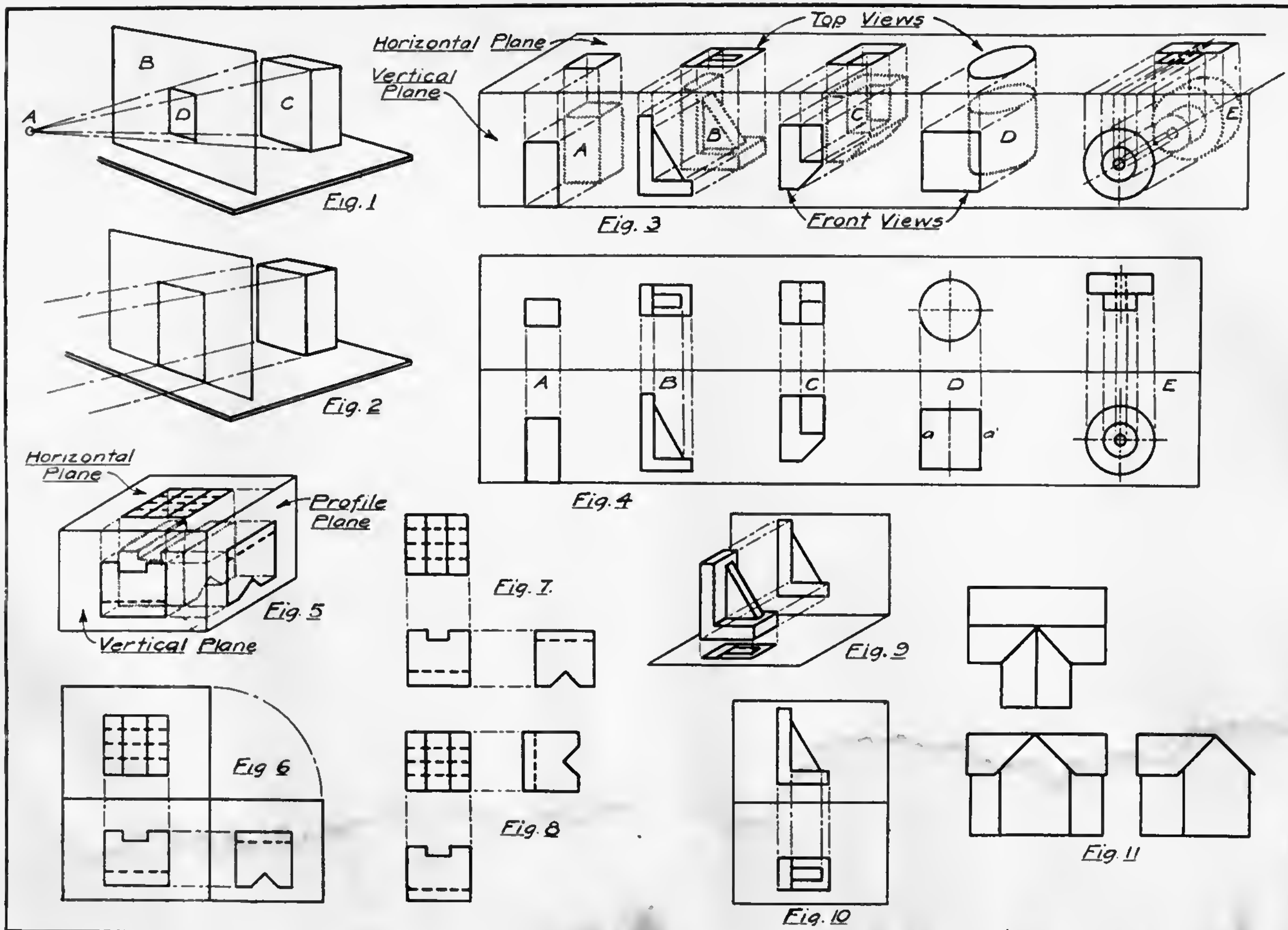
If one should take a pane of glass and hold it steadily between his eye and some object he desired a picture of, he might trace on the glass an outline of the object and this tracing would be an accurate perspective drawing. In Fig. I, Plate II, is a perspective drawing illustrating this. *A* represents the eye of the viewer, *B* the glass, *C* the object, and *D* the tracing on the glass of the object as it appears to the viewer. In other words, *D* is the perspective drawing of the object. Technically what we have represented as a piece of glass, is a picture plane. A plane is defined as that which has length and breadth but no thickness. It is of course not a material object, but it is convenient to use material objects, as glass or a sheet of paper by which to represent it.

In practice it is impractical to make drawings by the method illustrated in Fig. I, so draftsmen use a sheet of paper fastened to a drafting board, but the drawings are made exactly in conformity with the theoretical method just discussed.

In the preceding chapter we pointed out that perspective drawings were impractical as working drawings, due to the fact that as the distance of the object from the eye of the viewer increased the smaller it appeared. This can be seen by imagining the object in Fig. I to be at a greater distance away from the eye than shown. The tracing on the picture plane would decrease in size as the distance increased. The same result would occur if the distance between the eye and the picture plane were lessened. If the eye were directly against the picture plane, the tracing would become only a point. If it were the object that were placed against the picture plane and the eye were at a distance the tracing would appear the full size of the object itself.

Now, because of the practical impossibility of scaling a perspective drawing, as brought out by the discussion in this and the preceding chapter, and because a perspective drawing is a very complicated kind to draw—especially where it is of an object being designed and the object cannot be looked at, draftsmen have developed the system known as orthographic drawing or orthographic projection.

The theory on which orthographic drawings are made is a little more complicated than that for perspective drawings, but the drawings are vastly simpler, for the draftsman and, if he thoroly understands the theory, for the workman also. The success of this entire course depends very largely upon the student mastering the theory of orthographic drawing. Because of its importance it has been worked out step


A
B
C
D
Fig. 1
Fig. 2
Horizontal Plane
Vertical Plane
Top Views
Front Views
A
B
C
D
E
Fig. 3
A
B
C
D
E
a
a'
Fig. 4
Horizontal Plane
Profile Plane
Vertical Plane
Fig. 5
Fig 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11

by step with all of Plate II devoted to developing this theory.

In the preceding chapter, in the discussion of orthographic drawing, it was pointed out that an orthographic drawing was made up of two, sometimes more, "views" of an object. The use of the word "view" is not correct if used in the sense that it was used while discussing Fig. 1. In Fig. 2 is shown the same object and the same picture plane as in Fig. 1. The tracing on the picture plane, however, is a true orthographic drawing in that it is the actual size of the object itself. Note that the position of the eye of the viewer is not fixed. When a certain point on the object is to be traced on the picture plane the eye is moved so that it is directly opposite the point on the object. A better way to state this fact is, perhaps, that the line of sight must be kept perpendicular or "square" with the picture plane. This makes the lines of sight from all points on the object parallel with one another, and the tracing on the picture plane the full size of the object. Still another way to think of orthographic drawing is not to think in terms of views and tracings at all, but simply as a projection of the outline of the object to the picture plane by projection lines perpendicular to the picture plane. This is the way the draftsman usually thinks and for this reason he usually uses the term orthographic projection rather than orthographic drawing or tracing.

Reference to Fig. 2 shows that tho the projection, or tracing, on the picture plane shows the height and width of the object it does not show the thickness. It requires another view or projection to accomplish this just as it required two in the orthographic drawings on Plate I.

Fig. 3 shows several articles located beyond two picture planes—one located vertically before the objects and the other extending horizontally above the objects. On these planes are projections of the objects. The projection lines (or lines of sight, if you prefer) are shown by fine lines of alternate long and short dashes (—— - —— - —— - ——). Fig. 4 shows these two planes laid out flat as a draftsman would represent them on his drawing. The top views (or horizontal projections, since they are projections on the horizontal plane) are located directly above the front view.

Many objects can not be fully shown by two projections so that it is frequently necessary to add a side projection. Fig. 5 shows an object back of three picture planes and with projections of the object on the planes. Fig. 6 shows the planes opened up so

that the projections appear in the proper position they should appear in a drawing. Fig. 7 shows the three projections of the object as a draftsman would ordinarily represent it with the planes and part of the extension lines omitted.

In practice a draftsman never draws in the planes. He simply shows the two projections and leaves the reader to imagine the planes, but he always thinks of his drawings as being drawn on planes so it is necessary that the reader think of them in the same way. Often the draftsman omits the extension lines also, more often he draws them in pencil but does not ink them so that they do not appear on a blueprint.. Note that the extension lines (Fig. 4) are an aid in locating the same point in the different views. In the projections of the second article in Fig. 4, an angle block, the extension line locates the lower end of the brace piece. It is worth while to keep in mind that identical points on the different views of a drawing always are directly in line up and down or, in case of front and side views, horizontally. On complicated drawings it often is a great aid in reading them to lay a straight edge across from view to view to locate identical parts on the different views.

Instead of hinging the side plane (profile plane it is sometimes called) to the front or vertical plane as shown in Fig. 7, a draftsman sometimes hinges it to the top or horizontal plane. Fig. 8 shows the resulting arrangement of views while the planes themselves have been omitted. Such an arrangement often saves space on a drawing.

The arrangement of placing the horizontal plane above the object and the vertical plane in front is in accord with the best modern practice, but it is well to know that it was once customary to use the arrangement shown in Fig. 9. In this the vertical picture plane is placed behind the object and the horizontal picture plane below. The extension lines extend back or downward to the picture planes. When laid out flat as in Fig. 10 it will be observed that the top view comes below and the front view comes above. As some draftsmen, especially among architects, still use this arrangement it is well to know how to look upon it.

Fig. 11 shows a practical application of orthographic projection as applied to architecture, representing the horizontal, vertical and profile projections of a house, or in the terminology more common as applied to houses, roof plan, front elevation and side elevation. Note that the draftsman has in this followed the very common custom of omitting all extension lines, depending upon the proximity and location of the various views to show that they belong together.

QUESTIONS AND PROBLEMS.

1. Take a sheet of sketch paper and fold it at the center so that its two parts are at right angles like the vertical and horizontal picture planes in Fig. 3. Place these over a small rectangular block or box as the object *A* is placed in Fig. 3 and roughly sketch the top and front views. It should give views similar to *A* Fig. 4, but of a size depending upon the object used.

2. Use Section ruled paper. Draw a line down the middle lengthwise of the sheet to represent the line separating the two planes. Turn the sheet so this line is horizontal —runs right and left—and draw both the top and front views of a block 1 inch x 2 inch x 3 inch, getting your measurements by following the one inch square lines on your paper. Draw these free hand. Note the different arrangement or views resulting from different positions in which you assume the block to lie. Draw six complete drawings (both top and front views) showing the block in different positions.

3. Represent by two views as before a block one inch high, the top of which is 1¼ inches square. After completing the block represent a silver dollar as being on the block. Study carefully *D*, Fig. 4 and Fig. 3. After completing both top and front views of the dollar represent a smaller coin as being on the dollar. Note *E*, Figs. 3 and 4.

4. Draw plan and elevation (top and front views) of a cylinder 1½ inches in diameter and 2 inches high. When complete represent a hole thru it 1 inch in diameter. Note carefully the representation of holes in *E*, Fig. 4, and also the orthographic drawing of the cylinder on Plate I.

5. Draw plan, elevation and profile (three views) of a block 1½ inches x 2 inches x 2½ inches, as in Fig. 8. Represent a groove ¾ inch wide and ¼ inch deep as extending entirely around the block.

6. Make three views of object *B*, Fig. 3, increasing the size to more convenient dimensions.

7. Make three views of object *C*, increasing the size to more convenient dimensions.

8. Why would no advantage be derived from making a third view of objects *D* and *E*, Figs. 3 and 4?

9. What is brought out in Figs. 6, 7 and 8 by the third or profile view that is not clear from the other two views?

10. Sketch a three view drawing of a block 1 inch x 2 inches x 3 inches. Mark each of the block's eight corners by letters a, b, c, d, e, f, g, and h. Locate each of these eight corners in all three views. Better use a small block or box with the corners marked, as a model. Be sure each letter appears in all three views. Where two letters come in the same place on a view make the back letter a small one and the other a capital letter.

IV. MEANING OF VARIOUS KINDS OF LINES

The student has doubtless noticed that there is quite a variety of lines used in mechanical drawings. Each kind of line has its own meaning when on a drawing. Fig. 1, Plate III, has five different kinds of lines used in showing a simple square block with a square hole halfway thru it. There are fine solid lines, heavy broad solid lines, lines of dashes, lines of short dashes and a line composed of alternate two dots and a dash. Let us see what these various lines mean.

The fine solid line is used to represent (1) an edge where two surfaces come together, as the ridge line on the roof plan of the house on Plate II (Fig. 11); (2) where it represents a flat surface turned edgeways to the picture plane, as the edge of the block A, Fig. 4, Plate II and in Fig. 1, Plate III. (3) and where it represents that part of curved surface which is edge ways to the picture plane, as the lines *a* and *a′* as on the elevation of the cylinder in Fig. 4, Plate II.

Another line in Fig. I, Plate III, is the heavy broad line. It is called a shade line and is a conventionalized shadow. On all kinds of drawing, the drawing a viewer is looking at is supposed to be held vertically before the eyes, and the light is supposed to come over the left shoulder of the viewer. Shade lines represent such edges as separate surfaces turned towards the light from those turned away from the light—in other words they separate light from dark surfaces. Shade lines are not used by some draftsmen and not in every drawing by all draftsmen. Shade lines are a little troublesome to put in on a drawing but add to the appearance of a drawing and help to bring out the meaning. Note that in Figs. 1 & 2, Plate III, the top views are identical except for the shade lines. The use of these shade lines emphasizes the fact that the inside square on one view represents a hole while in the other it represents a projection. So clearly does it emphasize this, that if there were no occasion to show how deep the hole is or how high the projection is, the front views might be entirely dispensed with. Shade lines are very largely used for drawings of U. S. patents.

Two other lines on Fig. I, Plate III, are the broken or longer dashed lines and the dotted or short dash lines. The longer dashes are used as extension lines, that is lines extending from view to view to locate the same part on different views. As stated before, extension lines are often omitted by draftsmen where used for this purpose. Extension or dashed lines are also used to connect parts of the drawing with the ends of dimension lines. These dimension lines will be discussed later.

The dotted lines or short dash lines represent a hidden edge as the sides and bottom of the hole in the elevation drawing, Fig. I, Plate III. In Fig. 6 the

dotted line shows the bottom of the depression.

The line consisting of alternating two dots and a dash and extending entirely thru both views of Fig. 1, is a center line. Center lines divide views which are symmetrical. They are drawn in a variety of ways, tho the way shown, or one dot and a dash are the most usual ways. The center lines of Figs. 8, 10, and 11 are examples of the dash alternating with a single dot. In Fig. 2, the center line has two dots alternating with a dash. Center lines are occasionally drawn solid as in Fig. 3. They are always drawn fine, often the finest line on the drawings. Whatever way they may be represented they always represent an axes of symmetry and extend beyond the bounds of the drawings. Frequently a center line is circular as in Fig. 7, then it connects the centers of several similar parts—in this case several holes. Drill holes and usually all circular parts of drawings are crossed at the centers by two intersecting center lines at right angles to one another —Fig 7.

Another kind of lines also known as shade lines is shown in Figs. 4, 5 and 6. These are the fine lines drawn close together to give an appearance of the surface being curved. It is evident that Fig. 4 represents a cylinder tho but one view is shown. Fig. 5 is just as plainly a sphere supported by a circular shaft from a circular base. Tho the saving of a view would seem to justify frequent use of such lines on drawings, draftsmen do not generally use them except on patent office drawings, as these lines are often in the way of hidden edge and other lines.

A line or rather an arrangement of lines similar to shade lines is that shown in the drawing of the spool, Fig. 8. These are the parallel diagonal lines in the right hand "view." These parallel lines indicate that this is not an elevation or outside view, but is a cross section or view of the object after it has been cut on the center line. These parallel lines can be considered as the marks of the saw used in cutting it. These section lines are very frequently made freehand by architectural draftsmen especially where they represent a cross section of wood. Often a draftsman desires to show the kind of material at the same time he is showing a section view. Then instead of using the kind of lines in use in Fig. 8, he uses a kind of line or line arrangement which draftsmen have adopted as indicating the kind of material he wishes to represent. Fig. 9 is a chart showing cross sectionings in common use for different materials. Unfortunately, tho these sections are in common use, they are not recognized as universal standard conventions and for that reason it is not safe to depend upon them unless a note on the

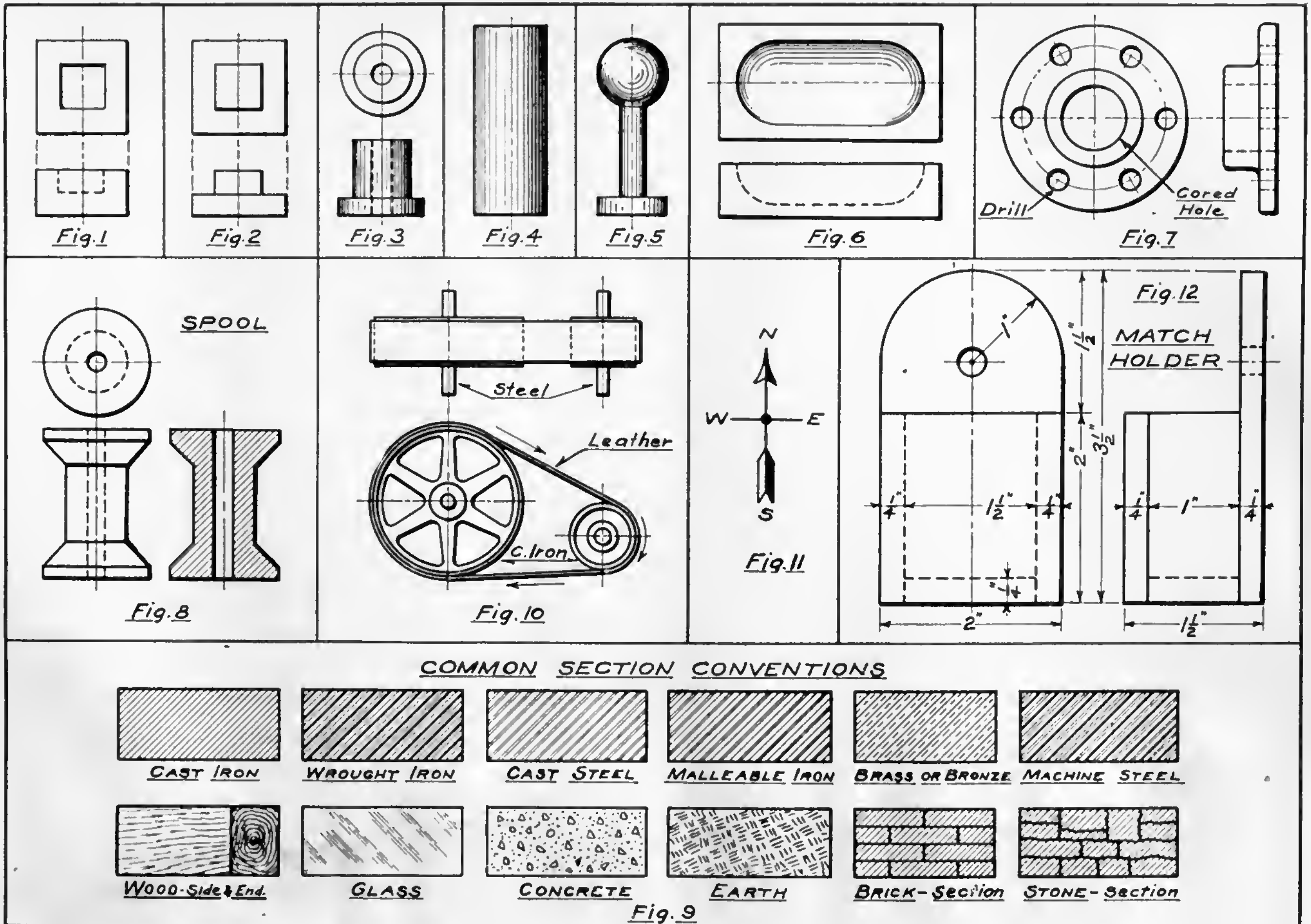


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Drill
Cored Hole
Fig. 7
SPOOL
Fig. 8
Steel
Leather
C. Iron
Fig. 10
N
W
E
S
Fig. 11
Fig. 12
MATCH HOLDER
1"
1½"
3½"
2"
¼"
1½"
¼"
2"
¼"
1"
¼"
1½"
COMMON SECTION CONVENTIONS
CAST IRON
WROUGHT IRON
CAST STEEL
MALLEABLE IRON
BRASS OR BRONZE
MACHINE STEEL
WOOD-Side & End.
GLASS
CONCRETE
EARTH
BRICK-Section
STONE-Section
Fig. 9

drawing names the material, or the convention is made standard by the drafting office from which the drawing comes.

More attention is given to the matter of sections in a later part of the course.

Arrow lines are conspicuous lines on most working drawings. They may serve to lead the eyes from some note to that part of the drawing to which the note applies, as the notes on Figs. 7 and 10. Such arrow lines may be drawn in freehand as is the one leading from the word "drill" in Fig. 7, or with a straight ruled line as the one leading from the words "cored hole". The arrow barbs, see Fig. 10, are drawn single or double as may please the draftsman, and without any particular meaning being attached to them.

In Fig. 10 arrows are used for another common purpose. They show the direction of movement of a moving part, in this case the direction of the rotation of the pulleys and belt. Arrows for this purpose are very frequently drawn with feather lines on the rear end of the shaft.

The arrow arrangement shown in Fig. 11 is frequently found with the drawing title on maps, and lot and foundation plans. It indicates the four principal points of the compass. On a foundation plan it readily shows the direction a building is to face. The initial letters are frequently omitted as the arrow invariably points directly north.

Another use to which arrow lines are put is shown in Fig. 12. It is to show dimensions. A dimension line ordinarily has an arrow at each end and with the length of the dimensions stated by the numerals near the center of the line. The shaft of a dimension line is made in various ways, the more common of which is a fine solid line broken for the numeral at the center. Other ways of making them will be discussed in a following chapter. Where one end of a dimension line is ended by a small freehand circle, as the 1″ dimension in Fig. 12, it indicates that the dimension is the radius of an arc of which the small circle is the center. When a dimension line is outside the view proper as the two 2″ and 1½″ dimensions in Fig. 12, short broken extension lines connect the tips of the arrows with the drawing to which the dimension refers. When these are drawn by a careful draftsman they do not actually touch the drawing.

This perhaps is an opportune place to remark that the grammar of drawing is as frequently violated as is the grammar of English, and we must learn to understand improperly drawn drawings, just as necessity requires us to understand the intended meaning and not the literal meaning of our fellow workmen.

QUESTIONS AND PROBLEMS.

1. What drawing in Plate I has lines showing hidden edges?

2. By what is it clear that the hole in the block shown in Fig. 1, Plate III, is not entirely thru the block as is the hole in the cylinder in Plate I?

3. How deep are the holes shown in Figs. 6, 7 and 8?

4. Were it not for the name, how would we know that the article shown in Fig. 12 would hold matches?

5. How many pieces to the Match Holder?

6. Using a sheet of section ruled paper to aid in getting the dimensions easily and correctly draw (1) a block with a top 1½ inches by 3½ inches, height or thickness of block to be 1 inch. The block to be represented as having a 1 inch by 3½ inch side towards the draftsman rather than the end. (2) Now, show a ½ inch square hole extending through the block, located ½ inch from the left end, otherwise in the center of the block. Use necessary dotted lines to show that the hole is entirely through the block. (3) Show a ½ inch square hole similar to the one just made except that it is but ½ inch deep. (4) Locate a ½ inch cube in the center of the remaining space on top of the large block. (5) Put in a center line on the axis of symmetry and dimension the entire drawing fully.

7. (1) On section ruled paper, redraw at a convenient size the objects on Figs. 3 and 4 of Plate II, adding side views and using shade lines.

8. Draw the cylinder in Fig. 3, Plate II, but instead of showing it by but one view and the kind of shade lines used in this drawing, show it by a top and front view without shade line. Use proper center lines. (2) Change drawing so that it represents a cylindrical open top box with ⅛ inch thick walls.

8. Draw Fig. 5, Plate III, omitting the shade lines but add a top view with the necessary hidden edge lines.

10. Represent Fig. 6 with a third "view" in section as is the spool in Fig. 8. Add overall dimensions.

11. Draw a number of simple objects, representing them by necessary center lines, hidden edge lines, etc. Use three views if necessary. Use shade lines only on very simple objects. Good models are ink well, tumbler, table knife, thimble, pill box, bolt, nut, etc.

V. FORESHORTENED LINES, INCLINED SURFACES, AUXILIARY PROJECTIONS

Draftsmen usually represent the objects they draw so placed that the surfaces of the object are parallel to the picture planes, as in the rectangular object in Fig. I, Plate IV. This is not always possible or convenient. Figs. 2 and 3 show the same object but turned so that the front face is no longer parallel to the front or vertical picture plane. The shaded surfaces in Fig. 2 are an unusual aid to the reader on the draftsman's part. He usually leaves the surfaces unshaded as in Figs. 1, 3 and 4, for to a skilled reader of drawings such aids to understanding a drawing, are unnecessary.

By the dimensions on the elevation of Fig. 1, we note that the width of the object is one-half inch, but if the reader should try testing the width of the elevations of the same object in Figs. 2 and 3, he would discover that they do not measure one-half inch. The more a surface or a line is inclined to a picture plane, the smaller it becomes. This shortening of surfaces and lines due to inclination is known as Foreshortening, and appears somewhere in almost every drawing.

In Fig. 4 the same object is shown as before but this time the inclination is towards the horizontal picture plane.

It will be evident by inspecting and a little scaling that a workman who attempts to scale a drawing, must carefully avoid trying to scale a line which is foreshortened. A draftsman never places a dimension on a line that is foreshortened.

In Fig. 5 is shown a very practical and frequent example of foreshortening. It represents the plan and elevation of a small building having its door and porch turned at 45 degrees to the main parts of the house. Note that all the lines on the porch except the vertical ones, are foreshortened in the elevation. If this is not clear try comparing the length of the lines representing the front and side of the porch floor in the two views. It will be noted that these lines will scale shorter in the elevation. This is because one end of these lines is nearer the vertical picture plane than the other, or in other words nearer to the viewer, but in the plan or top view these lines are parallel with the horizontal picture plane.

In Fig. 6 is seen another example of foreshortening in the drawing of the Angled Bearing Support. The effect of foreshortening is particularly noticeable in the front elevation representation of the circular opening where it appears not as a circle but as an ellipse. The side projection of this drawing is not like any represented heretofore. In fact it is not a side projection but what is called an auxiliary projection. A true side projection is a projection on a plane at right angles to both the horizontal and vertical planes.

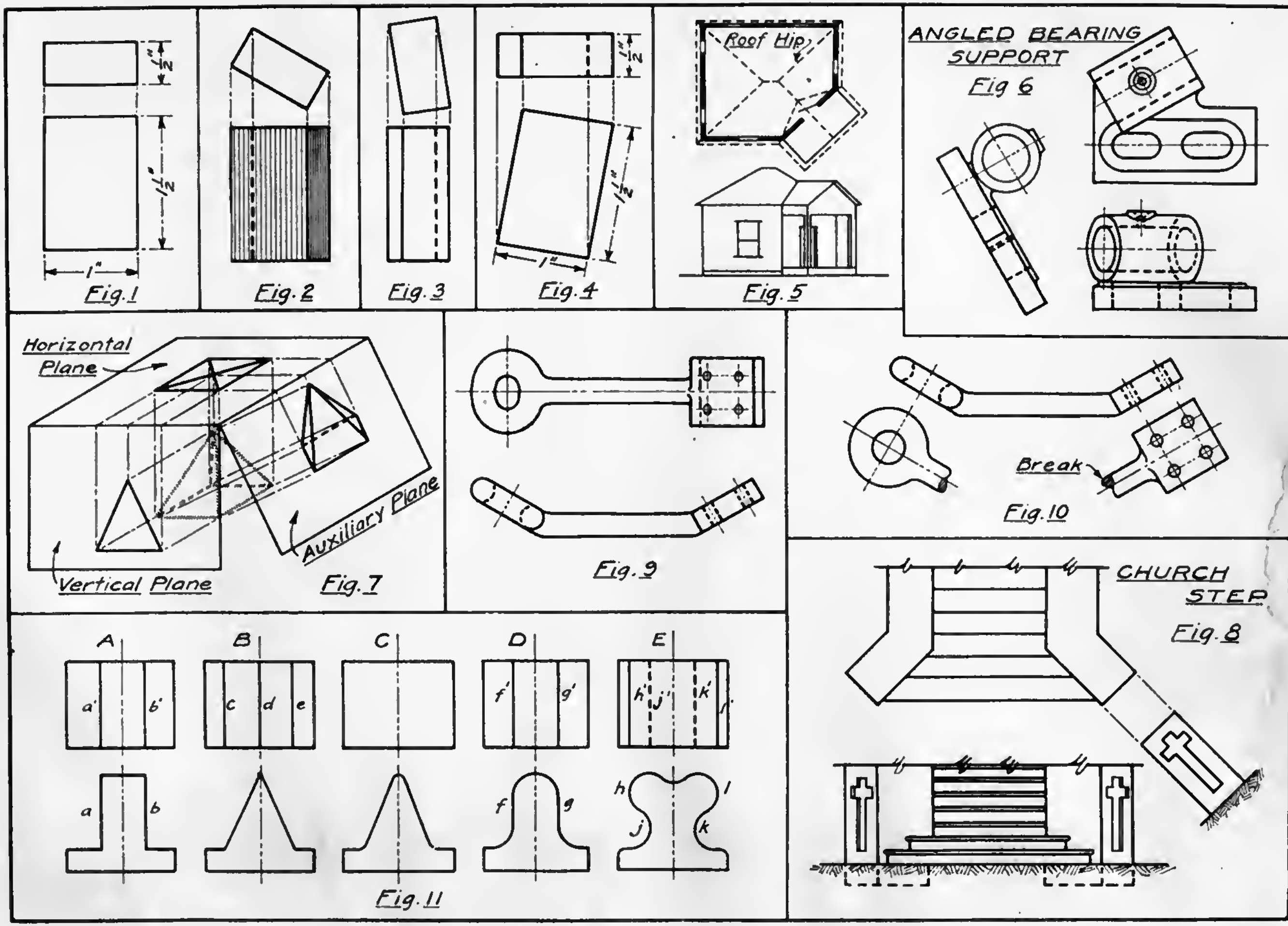


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Roof Hip
Fig. 5
ANGLED BEARING SUPPORT
Fig 6
Horizontal Plane
Auxiliary Plane
Vertical Plane
Fig. 7
Fig. 9
Break
Fig. 10
CHURCH STEP
Fig. 8
A
B
C
D
E
Fig. 11

Plate IV

An auxiliary projection is a projection on a plane perpendicular to but one of these, and is usually parallel to some surface on the object itself as in this case, the plane is parallel to the circular end of the bearing.

In Fig. 7 is shown the arrangement of planes necessary to secure an auxiliary projection parallel to the side of the object. Note that the auxiliary plane is placed so it is parallel with the face of the pyramid. This results in giving a projection of this face exactly the size of the face of the object. This is not the case in the front projection, where because the lower end of the front face is nearer the plane than the top, the surface appears slightly foreshortened in the projection. Were a workman trying to make this pyramid out of sheet metal this auxiliary projection would be the only one on which he could get a correct layout for cutting his metal. If he made his layout from a foreshortened projection he would not get the correct shape.

Note that the auxiliary projection in Fig. 7 shows not only the surface towards the auxiliary plane, but also two other surfaces. These two other sides are too much foreshortened to be of any value, so draftsmen often omit from such projections such parts of a drawing as they have no need for. The draftsman has done this in the auxiliary projection of the church steps, in Fig. 8. The plan and elevation show all that is necessary for the construction of the steps except that no parts of the plan or elevation represent the crosses in their true shape. Therefore, the draftsman has had to put in an auxiliary projection to show the true shape and size of one of these crosses. If he had drawn a complete projection of the steps it would have entailed as much drawing as for either his plan or front elevation, so he has drawn an abbreviated auxiliary projection showing only the end of the buttress which fully serves his purpose.

Occasionally auxiliary projections are the only satisfactory way of representing an object. Figs. 9 and 10 show an iron forging represented in two ways. In Fig. 10 the common arrangement of a horizontal projection is omitted and two partial auxiliary projections take its place and with much more satisfactory results. The horizontal projection in Fig. 9 has the most important parts foreshortened, the drill holes appear elliptical and the eye is not represented as being a true ring as it is intended to be. By using the two partial auxiliary projections, as in Fig. 10, the drill holes are shown to be round at their proper distances apart, and the eye of the rod is shown to be a true round ring.

Note the draftsman's use of a break to prevent his having to draw more of the projection than he had need for.

Closely related to the preceding discussions is the matter of what combinations and position of surfaces make line on a drawing. The rule is,—the boundaries of surfaces, perpendicular edges, and distinct intersections of surfaces are represented by lines on the picture planes.

Only such parts of an object as come within this rule can be represented on a drawing by lines unless shading of some sort be added. This is rarely practical for working drawings. Fortunately the application of the rule seldom leaves any parts of the object unrepresented on the drawing by lines tho it is frequently necessary to consider two projections or views at the same time in order to be sure of a surface.

The various kinds of ribbed pieces or moldings represented in the drawings grouped under Fig. 11 illustrate the application of the above and also emphasize that caution must be observed not to depend upon one view in reading a drawing. All the lines, except of course the center line, of the vertical projections (front views) illustrate all three classes of the rule—(1) boundaries of surfaces, (2) perpendicular edges, (3) distinct intersection of surfaces. The lines a', and b', of drawing A also represent all these classes. Lines c, d, and e, of drawing B illustrate clause 3—distinct intersection of surfaces. Note that object C is the same as B except that there is no distinct intersection of surfaces. The horizontal projection of C is an excellent illustration of the necessity of always considering all projections of a drawing at a time. If one were to consider the horizontal projection of C only he would be very likely to come to the erroneous conclusion that it represented a flat surface. There is no way for the draftsman to show by lines that this is not a flat surface except by depending upon the other projection or by resorting to shade lines or other means of shading. As the vertical projection—if the reader does not neglect to take it into consideration—makes the true shape clear, the draftsman would seldom resort to shading, as he has not resorted to it in this drawing. Draftsmen usually assume that those who are to read their drawings understand drawings as well as they do. The lines h', and g', drawing D illustrate clause (2)—perpendicular edges. They do not represent distinct intersections nor boundaries of surfaces. Lines h', i', j', and k' of drawing E also illustrate lines representing perpendicular edges. These edges are perpendicular only at places h, i, j and k but since they are perpendicular at these places they are represented by lines on the other projection. As illustrated by lines j' and k' hidden edge lines are subject to the same rules as visible lines.

QUESTIONS AND PROBLEMS.

1. What do the dotted lines on the elevations of Figs. 2 and 3 represent?

2. Has the revolving of the object in Figs. 2 and 3 affected the height any? Has it affected the thickness and width in the plans (top views)?

3. How many lines representing edges in Fig. 2 are foreshortened? Fig 3? Fig. 4?

4. There are six conspicuous lines in Fig. 5 that are foreshortened in both the plan and the elevation. (1) Which ones are they? (2) Were it necessary for the draftsman to represent them at their full length, what would be the only way to do it?

5. Why is the right hand side of the doorway in the elevation of Fig. 5 represented by two lines and the left by but one?

6. Is the cross in the church step buttress cut in or raised?

7. What does the freehand cross hatching at the bottom of the church step elevation represent? See Plate III.

8. What do you interpret the dotted lines at the bottom of the church steps to represent?

8. If the risers to these steps are 6 inches high, how high is the porch floor they lead to? A riser is the vertical member of an individual stair step.

10. If the stair treads are to be built 12 inches wide, how far should the walk layer stop his walk from the porch?

11. Is the eye of the forging Figs. 9 and 10 made of round or square stock?

12. What information do we have given as to whether the rod part of the forging is round or square?

13. Why are the center lines drawn thru the drill holes in Fig. 10?

14. Draw three views of some triangular object as a draftsman's scale, wood cutter's wedge, etc.

15. Draw the angle block in Plate II, Fig. 4B, so placed that it is at an angle with the vertical plane as are the blocks in Figs. 2 and 3 of Plate IV. Increase the size to a larger scale for convenience and accuracy and so that the drawing conveniently fills a sheet of sketch paper. Begin by drawing the top view or horizontal projection but turn it at an angle with the vertical plane just as the top views of Figs. 2 and 3 are. Then project lines down to locate corresponding parts on the vertical projection. Use section ruled paper as that is the easiest to work with. You can use the diagonal of the squares as the angle at which to turn your top view.

16. Draw three views of a carpenter's saw horse. Let each square on your paper represent an inch. Make the upper part 2 x 4 x 36 inches, the legs of 1 x 4's and place them 3 inches from each end of the 2 x 4. Make the horse 26" high. Place the bottoms of each pair of feet 14 inches apart. Put in necessary dimensions.

17. Copy the plan and elevation of the Building in Plate IV, Fig. 5, increasing their size to about four times that shown. Place so that the proportionate space between the views is about twice that shown. Draw an auxiliary view of the front of the porch just as the auxiliary view of the Church Steps was drawn on Plate IV.

VI. SCALE DRAWING, DIMENSIONS

It is often found impractical to make a drawing the full size of the object it represents. It is evident that it would be impossible to make the drawings of a building and many other objects full size, so draftsmen make the drawings of convenient sizes without much regard to the size of the object itself. However, there is nothing haphazard about the proportions between the drawing and the object itself. That is always carefully decided upon before a line of the object is drawn. Small objects are usually drawn ¾, ½, or ¼ the size of the object itself. With large objects such as buildings an inch or part of an inch represents a foot on the object itself. Thus, if a scale of one inch to a foot were used an object 24 ft. long would be represented as but 24 in. long on the drawing. If a scale of ¼ in. to the ft. were used the 24 ft. object would be shown by a drawing but 6 in. long.

The following are the more commonly used scales with their proper names.

Scales.	Names.
12 in.=1 ft.	.full size or scale
6 in.=1 ft.	.half size or scale
3 in.=1 ft.	.fourth or quarter size or scale
1½ in.=1 ft.	.eighth size or scale
1 in.=1 ft.	.one inch scale
¾ in.=1 ft.	.three-fourths or three-quarter inch scale
½ in.=1 ft.	.half inch scale
⅜ in.=1 ft.	.three-eighth inch scale
¼ in.=1 ft.	.one-fourth or quarter inch scale
3/16 in.=1 ft.	.three-sixteenth inch scale
⅛ in.=1 ft.	.eighth inch scale

Care should be taken not to call interchangeable the names of such scales as half scale and half inch scale. One represents 6 in. as equal to a foot and the other ½ inch as equal to a foot.

Drawings drawn to scale should always be accompanied by a note stating the scale of the drawing. This is usually placed as part of or accompanying the title. Note the statements of the scale of the various drawings on Plate V. These statements of the scales of the drawings are often of aid to the workman when he finds it necessary to scale a drawing for a dimension. They are also an aid in forming a proper mental image of the actual size of the object.

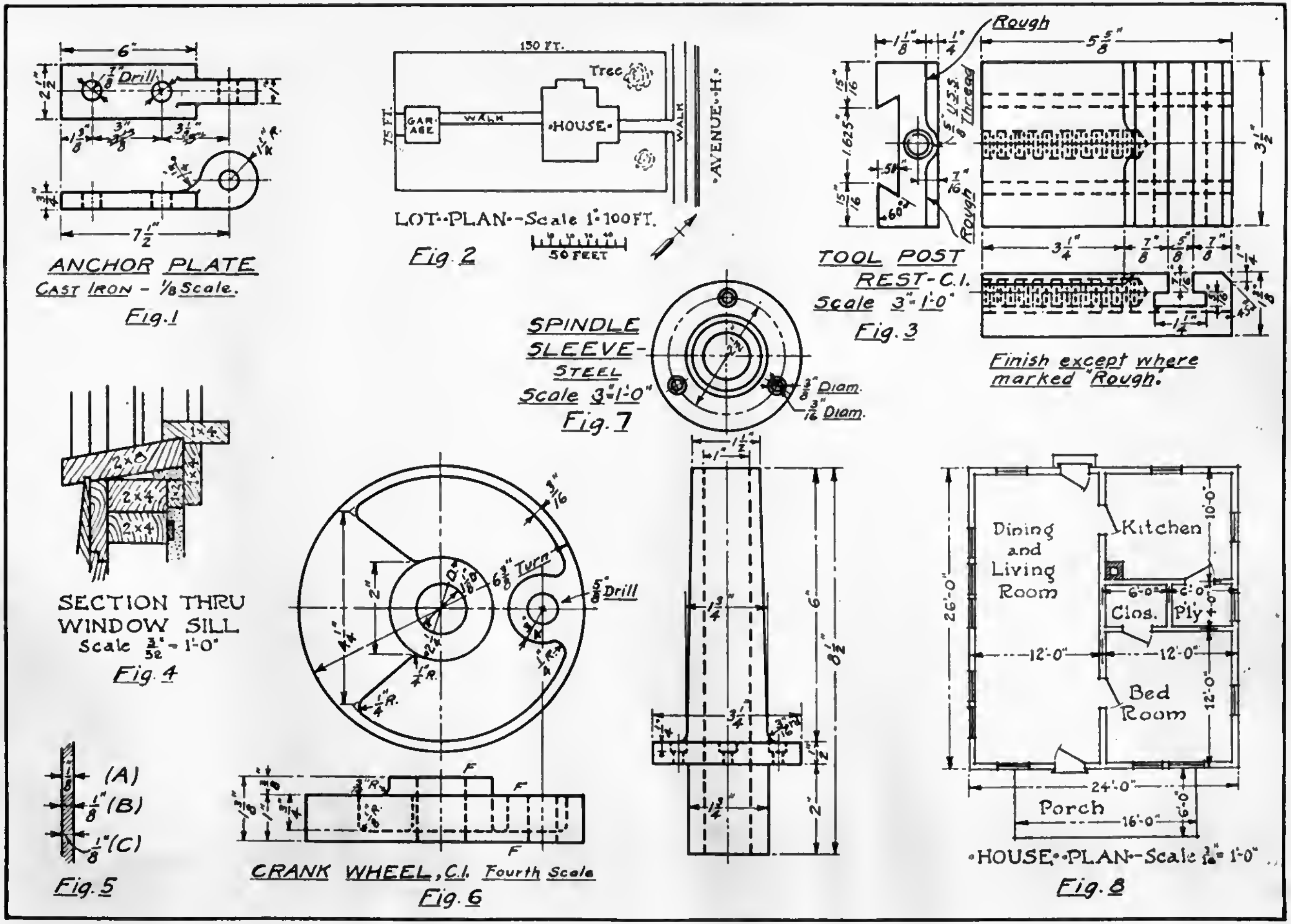
A properly made drawing should ordinarily not require any scaling on the part of the workman. All dimensions necessary for the workman should be on the drawing and if they are on the drawings they should be depended upon and not any scaling on the part of the workman. This is for two reasons. First, blueprints are thoroughly washed during the process of printing and while wet are likely to be more or less stretched out of their proper size. Second, draftsmen are not as particular about the accuracy of their draw-

ings as they are about the accuracy of the dimensions. They expect the workman to use the dimensions that they give. If the draftsman while making a drawing discovers that he has drawn part of his drawing wrong or out of scale, he very frequently puts in the proper dimensions and leaves the drawing unchanged. If a change of size should later be considered desirable, it is quite customary to change the dimensions without changing the drawings. This is entirely satisfactory if the workman will depend upon the draftsman's dimensions and not upon some of his own which he has arrived at by scaling. Where a change of this nature is to be made it is good policy on the draftsman's part to simply cross out the old dimensions and write in the new above as has been done in Fig. 1, Plate V. The draftsman probably discovered that if the object were made with the drill hole located as drawn there might be interference between the web connection, between the eye and the plate, and the nut of the bolt to be used in the drill hole. As a change of the drawing involved considerable erasing he simply made the necessary corrections by a change in the dimensions and if the workman depends upon these dimensions, instead of scaling, the Anchor Plate will be made exactly as the draftsman intended it should be.

This drawing illustrates, however, a good example of a very proper place for scaling, as the draftsman has omitted a dimension for the hole in the eye. The only way for the workman to determine this is to scale the drawing.

Where an unusual scale is used or one not readily read from an ordinary rule, the statement of the scale is usually accompanied by a line divided into divisions in accordance with the scale. This is illustrated by the Lot Plan, Fig. 2 where a scale of one-half inch equals 50 ft. is used on the drawing. As few people would have a rule having 100 divisions or multiples of 50 on it the draftsman has divided a one-half inch line into divisions convenient for scaling of the drawing. The reader should use a pair of dividers in taking off dimensions if he has them. If he has not he can use a strip of paper marking off distances on the edge with a sharp pencil point.

Fig. 2 illustrates a method of marking distances or dimensions without the use of dimension lines. The dimension is simply written on the line which is the length stated by the figures. Thus the dimensions 75 ft. and 150 ft. indicate that the boundary lines on which these lines are written are of these lengths. This method of dimensioning is used a good deal on map drawings and occasionally on very simple working drawings. It is not a very satisfactory method as dimensions so written can often be misinterpreted. Thus, the reader might interpret the 150 ft. dimensions


ANCHOR PLATE
CAST IRON - 1/8 Scale.
Fig. 1
LOT-PLAN-Scale 1"=100 FT.
150 FT.
75 FT.
GARAGE
WALK
HOUSE
Tree
AVENUE H.
50 FEET
Fig. 2
TOOL POST REST-C.I.
Scale 3"=1'-0"
Fig. 3
Rough
Finish except where marked "Rough."
SPINDLE SLEEVE-STEEL
Scale 3"=1'-0"
Fig. 7
SECTION THRU WINDOW SILL
Scale 3/32"=1'-0"
Fig. 4
(A)
(B)
(C)
Fig. 5
CRANK WHEEL, C.I. Fourth Scale
Fig. 6
Turn
Drill
Dining and Living Room
Kitchen
Clos.
Ply
Bed Room
Porch
HOUSE PLAN-Scale 1/8"=1'-0"
Fig. 8

to be 150 ft. to the fence line, walk line, curb line or even the street center.

The method of dimensioning used in Fig. 1 is the method in most general use and is by far the most accurate. The numerals indicate the dimensions in feet or inches or feet and inches from end to end of the dimension line on which the numerals are written. Note that ends of dimension lines are terminated by arrows and dimensions always read from Tip to Tip of arrows. The most common error in reading dimensions is in noting the reading of the numerals but not noting carefully where the Tips of the arrows terminate. A careless glance at the dimensions of Fig. 1, might lead one to read over all length of the Anchor Plate as being 7½″ while a careful noting of the tips of the arrows show that it is 7½″ from one end to the center of the eye near the other end.

The marks ″ over the numeral as with the dimensions in Fig. 1 indicate inches, while ′ indicates feet. The abbreviation "ft." is frequently used also to indicate feet as is done in Fig. 2. Where feet and inches are used together a dash should separate them. In dimensions given in inches only, the abbreviation marks are often omitted, but a careful draftsman would never do this on an object where there might be any doubt as to whether inches or feet were intended. It can be readily understood that any draftsman might omit these comparatively inconspicuous marks on a particular dimension. Do not hastily read this to mean inches unless he has left the marks off of the entire drawing. If the dimension numeral is a mixed number as 5½ you can be quite sure it is intended as 5½ inches as a careful draftsman never uses the dimensions 5½ ft. He would use 5 ft. 6 in. (5′-6″.)

The mark ° over a numeral means degrees, thus, 45°. This means that the two lines or surfaces indicated by the two arrows leading from the numerals so marked are to be constructed at an angle 45° with one another. In Fig. 3 are two examples of where surfaces are indicated to be at definite angles to one another—one 60° and the other 45°.

In machine drawings it is often necessary to indicate to some degree how nearly accurate a dimension is to be adhered to. It is evident that for the purposes of a brick mason dimensions to the size of the nearest multiple of the width of a brick is all that he needs ordinarily, but the machinist who is making a gasoline engine piston head to fit a ground cylinder must do his measuring in thousandths of an inch, and the draftsman must have some way of indicating to what degree of accuracy the dimensions he gives are to be adhered to. This is done by using decimal fractions. To illustrate, if a dimension reads 4.5″ it would indicate that the range of permissible variation was

between 4.4″ and 4.6″. If the draftsman wishes the dimensions to be more rigidly adhered to, he states it 4.50″ which would then allow but a variation between 4.49″ and 4.51″. Of course the same system of obtaining greater accuracy would apply if the dimensions were stated 4.5000″.

Another way of stating the permissible variation—tolerance, is the technical term—is by stating the dimension thus,—$\frac{4.4''}{4.6''}$, $\frac{4.49''}{4.51''}$, or if a greater range of tolerance is wanted $\frac{4.45''}{4.55''}$

The following examples will illustrate proper ways of stating dimensions.

18″	Eighteen inches.
18	Eighteen inches.
1′-6″	One foot six inches.
1 ft. 6″	One foot six inches.
5′-0″	Five feet.
5 ft.-0″	Five feet.
5′-1¾″	Five feet, one and three-fourths inches.
5.25	Five and one quarter inches with a tolerance of 2/100 inches.
$\frac{5.20}{5.30}$	Five and one quarter inches with a tolerance range of 20/100 of an inch.
15°	Angle of fifteen degrees.

A simple way of dimensioning frequently used in architectural work is shown in Fig. 4. The size of the pieces are simply written in on the drawing of the pieces. It is customary to use the approximate sizes only. Thus the 2x4 in Fig. 4 would in reality be 1⅝″x3⅝″. This method is also used in indicating the approximate size of rooms on floor plans. The inch and foot marks are ordinarily omitted as it is usually clear which is intended. It is seldom used in machine drawing.

Where space is too crowded to show dimension lines by the regular arrangement of arrows the arrangements shown in Fig. 5, are used. The arrows are reversed in position but the dimension is from tip to tip of arrows just as in the normal arrangement. This arrangement has been used in one or two dimensions in Figs. 1, 3, 5, 6 and 7.

It will be noted that all dimensions read from either the bottom or right hand side of the drawing. A careful draftsman never makes exceptions to this arrangement. Note that dimension lines are shown in different ways in the various drawings on this sheet. A draftsman usually adopts a certain kind of line and always uses it, but this plate illustrates the various ways in common use. The arrangement of a fine solid line broken in the center for the numerals is undoubtedly the most generally used and probably, all things considered the best. If the lines are long many draftsmen

break the line in several places as is shown in Figs. 6, 7 and 8.

Figs. 7 and 8 show variations used by some draftsmen. In spite of this apparent lack of uniformity there is little likelihood of the reader mistaking a dimension line for some other kind of line, if he keeps in mind that dimension lines always have arrow heads at either end and a numeral is placed at the center.

Where arcs are to be dimensioned the radius dimension is given with one arrow on the arc end of the dimension line and a small freehand circle at the center end. A few draftsmen use a small cross at the center end. Many draftsmen put neither a cross nor a circle at the center as these add little to the clearness of the drawing. The numerals of radii dimensions are usually accompanied by abbreviations of the word radius—R., Rd., Rad., r., rd., rad. Note examples of radius dimension in Figs. 1, 6, and 7.

Diameter dimensions are frequently accompanied by abbreviations for the word diameter—D., Dia., Diam., dia., diam. Note diameter dimensions in Fig. 7.

Let us take a drawing and see how much information we can get from it. Fig. 3 looks a little complicated so we will study that. First let us note the name —Tool Post Rest. If we are familiar with a machine lathe the name tells us a whole lot. The scale (one-fourth) gives us an idea of its size. We note its three projections or views and their relation to one another. By their relations to one another we realize that the largest of the three is the top view or horizontal projection and the others are side and front projections. Looking at the overall dimensions we find that it is 5⅝″ long, 3½″ wide and 1⅜″ high. The first two of these dimensions are given on the top view, the height is given on the front view. It could also be found by adding the 1⅛″ and ¼″ dimensions on the end (or side) view. It is also discovered to be approximately a rectangular solid in shape.

Probably the most conspicuous variation of the object from a rectangular solid is found probably first in the end view where a dovetail groove is shown on the bottom. Dotted lines on the other views, one on the front view and four on the top view show that this groove goes the entire length of the object. The dimensions show that this dovetail is ½″ deep and 1⅝″ wide. As these dimensions are stated decimally—.50″ and 1.625″, these dimensions are evidently to be very closely adhered to by the workman. The 15/16″ dimensions on either side of the 1.625″ dimensions shows that this dovetail groove is placed exactly in the center of the object. The 60° angle dimension at the side of the dovetail groove shows the angle which the side of the groove makes with the bottom of the object.

The conspicuous mass of dotted lines in the top and

front views must represent a threaded hole. This surmise is proved by the concentric circle and near circle on the other view. The circle represents the inner edge or top of the threads, the near circle the bottom of the threads. The note, "5/8 U. S. S. threads," shows the diameter of the hole and that the threads are ordinary United States Standard threads. The horizontal (left to right) center line passing through the threaded hole shows that it is in the center of the piece.

The most conspicuous thing which the front view brings out is the inverted "T" groove near the right hand end. Glancing back to the top view we see that this groove is shown on this view by two solid lines and two hidden edge lines. These establish the fact that this "T" groove runs entirely across the Rest. Inspection of the end view fails to show any trace of this groove though two hidden edge lines should be there. The draftsman has evidently decided that the groove was fully shown by the other views and has made use of his privilege of omitting anything on a drawing which does not give increased information. The dimensions show that this groove is 5/8″ wide at the top and 1 1/4″ wide at the bottom, the narrow part 7/16″ deep and the wide part 5/16″. The dimensions also definitely locate the position of the groove as being 7/8″ from the right hand end of the Rest.

While getting this information the reader has doubtlessly discovered that the top is not flat as he may have supposed it to be at first glance. He has probably discovered that the right hand end of the top is chamfered off at the corner. The dimensions show that this chamfer (or bevel) is 1/4″ wide and at an angle of 45° with the end. The left end is more modified still. The end view shows that a curved ridge extends along the top directly over the tapped 5/8″ hole. This is evidently intended to thicken the metal along this hole without adding to the entire block. That this ridge does not extend entirely across is shown in the top and front views. The front view shows this by a solid line representing the flat surface at the side of the ridge, showing that it dies away in a rise of the surface 3 1/4″ from the left end. The top view shows this ending of the ridge by a curved line of intersection.

If this ridge had made a distinct line of intersection with the top instead of flowing into it with a flowing curve, as shown on the end view, the sides of the ridge would have made lines on the top view.

This discussion of what is shown in the drawing of Fig. 3 certainly shows that the great universal language of mechanical drawing, is an exact expressive compact language, much better suited to the purpose for which it is used than any other language could hope to be.

QUESTIONS AND PROBLEMS.

1. Assuming that the house in Plate IV is 20 ft. by 24 ft., what scale is it drawn at?
2. What are the over all dimensions of the house in Fig. 2, Plate V?
3. What direction does the house front?
4. Is the House Plan, Fig. 8, one-sixteenth scale or one-sixteenth inch scale?
5. What are the overall dimensions of the Anchor Plate?
6. In dimensioning radii in the Angle Plate, which has the draftsman made use of, for the center of his dimension line, the small freehand circle or the cross?
7. What has he used as his abbreviation for Radius?
8. Where might he have used the abbreviation for Diameter?
9. What are the dimensions of the drill holes in the Anchor Plate? The Eye Hole?
10. What is the short width of the dovetail groove in the Tool Post Rest? The depth? What angles are the side at?
11. What is the approximate depth of the tapped hole?
12. How many pieces of two inch lumber are shown in cross section in Fig. 4? One inch?
13. What do you interpret the sections on Fig. 4 shown as fine scattered dots to represent?
14. How many examples of the Fig. 5 (A) style of dimensioning do you find on this sheet? (B)? (C)?
15. What is the diameter of the Crank Wheel? Width of the wheel face? Diameter of the hub?
16. The draftsman has neglected to put in what is from the standpoint of his entire machine probably the most important dimensions on the drawing. Where is it? What should the length be as you scale it?
17. What are the diameters of the holes through the wheel?
18. How can you tell center lines from dimension lines in Fig. 7?
19. What is the diameter of the large hole through the Spindle Sleeve?
20. Why are two diameters given for the three holes through the flanges of the Spindle Sleeve?
21. How far are the centers of those holes from the center of the Sleeve?
22. How many square feet of lumber will it take to cover the porch of the house, Fig. 8, allowing ¼ for waste?
23. Allowing walls to be 6 inches thick, what is the actual inside size of the Bed Room?
24. Which is the larger on the inside, the Closet or the Pantry?
25. Draw a full size drawing of an ink bottle and give the principal dimensions. Do not neglect to put in center lines.
26. Draw a water tumbler or tin cup half scale and dimension.
27. Draw a box similar to the one on Plate I stating the scale and dimensioning so that the full dimensions of every piece in the box are fully given. Draw 3 projections.

VII. BREAKS, REPRESENTING DRAWINGS AS BROKEN

Draftsmen very frequently draw objects represented as tho they had gone thru some serious accident—they represent the objects as being broken. Sometimes an end is broken off, often the part broken out in the center. The draftsman does not want the workman to make the object broken as represented, but the break is put in the drawing simply as a convenience to the draftsman. The most frequent use of the break is probably to save drawing space. The break in the Drafting Tee-Square in Plate VI was for that purpose. By breaking a piece out of the blade of the Tee-Square the draftsman was able to shorten his drawing by over half. Scaling will show that he had represented the 36″ blade as only about 11″, tho the dimension reads 36″. Of course the workman is to make it a perfectly good Tee-Square and full 36″ long. It is evident that dimension lines and not scaling must be relied upon in reading a dimension extending across a break.

The Connecting Rod End is a good illustration of another use of a break—to show only a part of an object. Evidently the draftsman did not consider it necessary to represent the entire Connecting Rod so he broke off the desired part. It is evident that the arrangement of his projections also forced him to resort to breaks to prevent his projections from conflicting. This same necessity for breaking the drawing occurred in Fig. 10 of Plate IV.

Note in the Connecting Rod End the use of cross hatch (close parallel) lines to indicate the broken surface. Note also the peculiar shape of the break itself. This way of representing a broken cylindrical or elliptical part is almost universal. Note the way of representing the breaks in the Broken Cylinder and the Broken Pipe.

In small parts the broken surface is often represented in solid black (white on blueprint, of course). This is illustrated by the Broken T-iron, and the Clamp Lever.

Wood is usually represented by a more ragged break line than iron as shown in the drawing Broken Wood, and Pier and Framing, tho this is not always the case.

The left hand break in the Lathe Tail Stock Spindle Sleeve and the break in the Collar and Button Box, represent a use of the break for the purpose of showing parts in the interior of the object. In the Collar and Button Box the draftsman has broken a hole in the side of the outer part of the box so that the button box part shows through the break. In the case of the Spindle, by breaking away the end the draftsman has been able to represent a section of the brass threaded

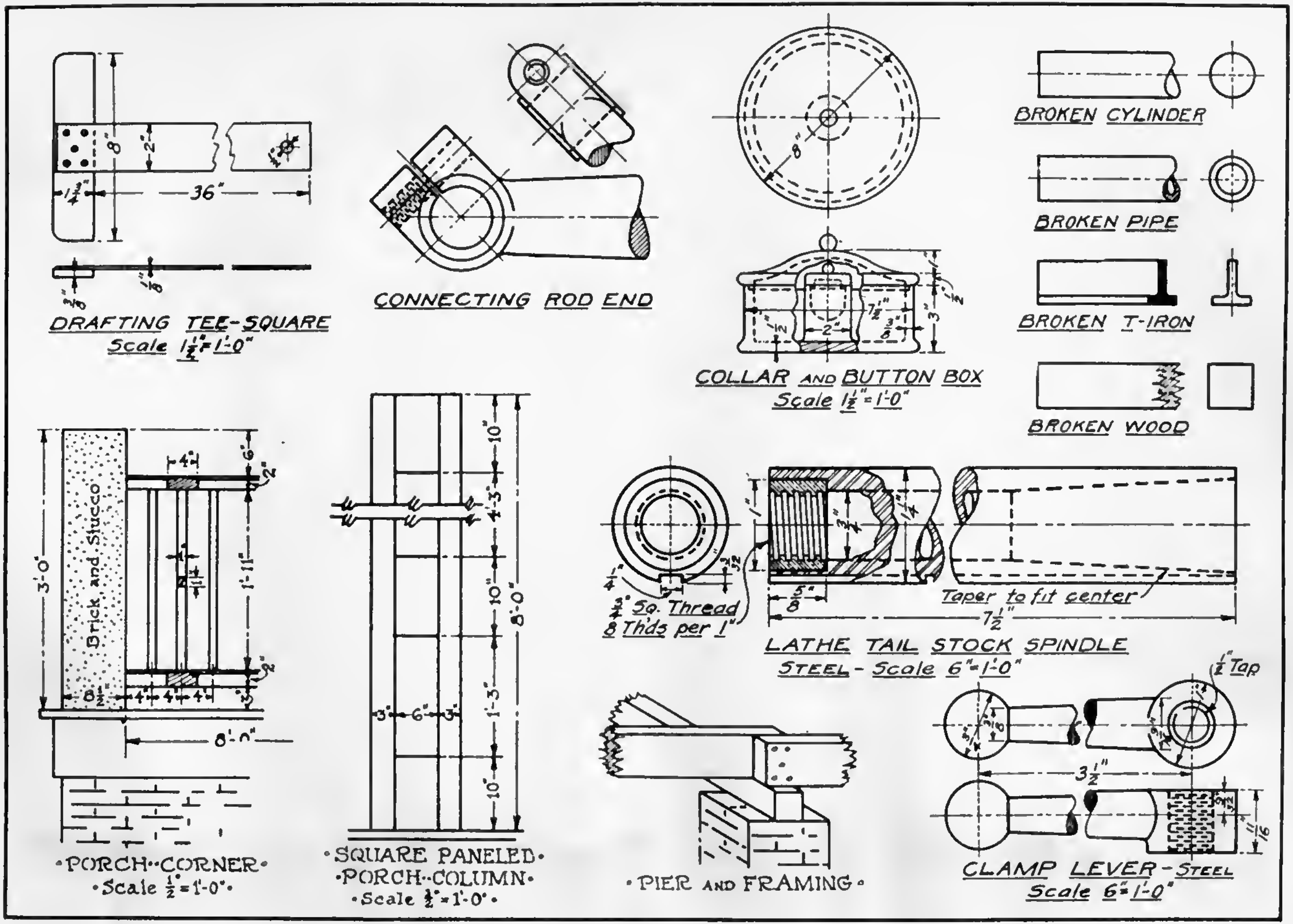
collar much clearer than would have been possible by hidden edge lines.

Often a part of an object is shown without a distinct breaking off line being shown, as illustrated in the Porch Corner. Here the lines representing the porch rails are simply stopped after they have been drawn as long as is necessary for the purposes of the draftsman, no distinct breaking off line being shown. This is very frequently used by architectural draftsmen, but not so much by machine draftsmen. Note that even the dimension line is broken off. This is not often done, however, as nothing is definite as to what the other end of the object is like.

The Porch Column shows a way of representing a breakline used very largely by architects. It is little used by machine draftsmen. The break line is drawn partly with a straight edge and partly free hand.

QUESTIONS AND PROBLEMS.

1. What changes would be necessary in the drawing of the Drafting Tee-Square to represent a 30 inch Tee-Square?
2. What dimensions are omitted in the Tee-Square that might be put in if the draftsman were unwilling to trust to the judgment of the workman?
3. What projections (or views) has the draftsmen made use of in the Connecting Rod End?
4. If we consider bricks to be 2 inches x 4 inches x 8 inches, what is the width and thickness of the pier in the drawing Pier and Framing?
5. What kind of drawing is the Pier and Framing? Refer to chapter I if necessary.
6. What do the hidden edge lines in the top view of the Collar and Button Box represent?
7. Is the Button Box part round or square and how do you know?
8. Why are no dimensions given for the taper in the Lathe Tail Stock Spindle?
9. What besides the end view shows that the Spindle is both round and hollow?
10. What are the dimensions of the small brass piece in the Spindle?
11. How long over all is the Clamp Lever?
12. What besides the dotted lines showing threads shows that the hole in the Clamp Lever is threaded?
13. Since no end view is shown, how do you know that the tapered bar to the Clamp Lever is round and not square? There are two distinct things that show it?
14. Does the keyway in the Lathe Tail Stock Spindle extend the entire length of the spindle?
15. Add the smaller vertical dimensions on the Porch Column to see if they agree with the stated over all height of 8 feet.
16. How many linear feet of corner boards would be needed?
17. Allowing 3 inches for lap and waste on each piece, how many linear feet of lumber would be needed for the panels of the Porch Column?
18. How many linear feet of 2 inches x 4 inches would be needed for the hand and bottom rails of the Porch Corner?
19. How many linear feet of 1 inch square lumber would be required for balusters, allowing 1 inch waste on each baluster?


DRAFTING TEE-SQUARE
Scale 1½" = 1'-0"
CONNECTING ROD END
COLLAR AND BUTTON BOX
Scale 1½" = 1'-0"
BROKEN CYLINDER
BROKEN PIPE
BROKEN T-IRON
BROKEN WOOD
Brick and Stucco
·PORCH·CORNER·
·Scale ½" = 1'-0"·
·SQUARE PANELED·
·PORCH·COLUMN·
·Scale ½" = 1'-0"·
¾" Sq. Thread
8 Th'ds per 1"
Taper to fit center
LATHE TAIL STOCK SPINDLE
STEEL - Scale 6" = 1'-0"
·PIER AND FRAMING·
½" Tap
CLAMP LEVER - STEEL
Scale 6" = 1'-0"

VIII. SECTIONS

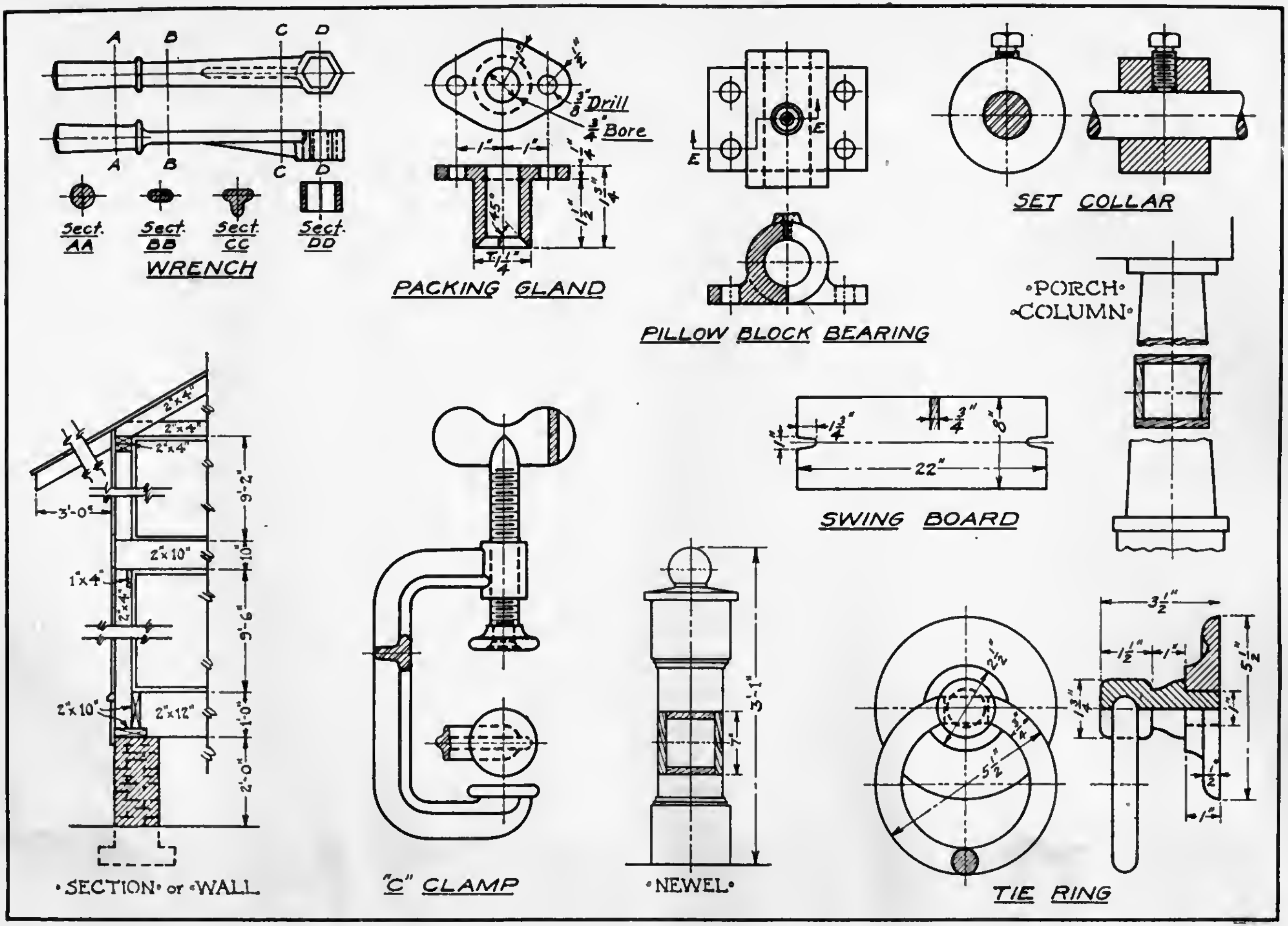
Draftsmen frequently represent parts of objects as they would appear were the object cut in two. Drawings which represent this cut surface are known as sections. Such a drawing was illustrated in Fig. 8, Plate III.

Sections are usually represented with closely drawn parallel lines (cross hatching) covering the cut surface. These lines can be considered as representing scratches left by the saw in cutting the object. Whether or not this is what they are supposed to represent, it is a simple interpretation that if kept in mind helps one to understand the meaning of a cross section.

Sections are usually made along center lines as was done in the case of the Spool Fig. 8, Plate III, but this is not always the case. Where such is not the case lines similar to center lines are drawn on the main drawing to locate where the section is to be made. This is illustrated in the drawing Wrench, Plate VII. The small circular drawing "Section AA" is a drawing of the end of the handle of the Wrench were it sawed off on the dot-and-dash line crossing the two views of the main drawing and marked with a capital "A" at either end. The other sections "BB", "CC" and "DD" represent other sections on similar lines.

Sections often represent more than just the surface cut in that they may represent a part of the object which would appear in the background after the section is cut off. This is illustrated by the section "DD" of the Wrench, where two horizontal lines represent the top and bottom of the back part of the opening for the nut, and a central vertical line represent, the back corner of the same opening.

Often instead of drawing small section views off to one side the draftsman draws the section on the main drawing itself as has been done in the drawing of the "C" clamp. Here the draftsman has drawn a small "T" shaped cross section on the frame of the clamp which is to indicate that the frame at this point is the shape of the section. He has also drawn in a small section on the wing of the thumb screw which shows the thickness and shape of the part there. These sections make it unnecessary for any top or side view being drawn altho the draftsman has had to draw a small auxiliary view to show the shape of the anvil of the clamp.



Sect. AA
Sect. BB
Sect. CC
Sect. DD
WRENCH
Drill
Bore
PACKING GLAND
PILLOW BLOCK BEARING
SET COLLAR
•PORCH•
•COLUMN•
2"x4"
3'-0"
9'-2"
2"x 10"
10"
1"x4"
9'-6"
2"x10"
2"x12"
1'-0"
2'-0"
22"
SWING BOARD
3'-1"
7"
•SECTION• or •WALL
"C" CLAMP
•NEWEL•
TIE RING

The Newel also illustrates the use of this same kind of section. The section drawn on the face of the Newel shows that the central part is square and is framed up of four boards. It also shows the dimension of this part.

The cross hatching of wood is usually done free-hand, as is done in this Newel section, and in such a manner as to represent the grain of the wood.

The sections in the "C" Clamp and Newel are known as revolved sections as they represent sections revolved at right angles with the main part of the drawings.

The balusters and rails on the Porch Corner, Plate VI, show further examples of the use of the revolved section.

Occasionally only a small part of a revolved section is drawn as the section representing and showing the thickness of the Swing Board. Here the draftsman has saved himself the labor and space required for a second view by inserting this small partial or broken revolved section. He could very easily have represented the section on the wing of the thumb screw of the "C" Clamp in the same way.

Closely related to these revolved sections is the inserted section illustrated in the Porch Column. In these the section is revolved but is inserted in a broken out space. These are very handy to use on a tapered part like the Porch Column where the taper would make it awkward to use a simple revolved section.

Often a section is used in place and in the position of the view. This was done in the section on Plate III where a section of the Spool was used for the side projection. In the drawing of the Packing Gland, Plate VII, a section is used in place of the front projection. Where this kind of section is used it is almost always a section on the center line of the object.

The Set Collar is another example of where a section is used in place of a projection. Note that while the Set Collar itself is rendered in section—right hand projection—the shaft and set screw are not sectioned. This is in accord with almost universal custom among draftsmen—cylindrical parts inside of sectioned parts are not rendered in section.

Often draftsmen use as a combination a regular outside view and a cross section, rendering half in section and half as an ordinary outside view. An example of this arrangement is found in the Tie Ring where the right hand view is rendered with the part above the center line in section and the part below as

an ordinary projection. This is a very satisfactory way of drawing objects which are symmetrical with a center line. The section shows the inside construction much clearer than hidden edge lines could do, while the part not rendered in section clearly shows the outside of the object.

The Pillow Block Bearing is another example of half view half section, the dividing line being on the vertical center line. Note, however, that the section is not along the horizontal (top view) center line but is along a zigzagged section line marked "EE". This is quite common practice and enables the draftsman to make his section give a greater amount of information than he might otherwise. By zigzagging his section line he has made his section show both a bolt hole and the oil hole which could not have been done by a straight cut out section. This zigzagging of the section line is very handy in house plans where it enables the architect to make a choice of rooms to show in his cross section views.

The section line "EE" on the Pillow Block Bearing has arrows on the ends. These arrows indicate the direction in which the reader is to consider himself as looking when reading the section view. These arrows are hardly necessary on this drawing because the location of the section itself shows the direction the section is to be considered as being viewed from. On house drawing, where each view and section has to be on a separate sheet of paper, these arrows are frequently of considerable help in reading a drawing.

The drawing Section of a Wall illustrates some common practices in making house sections. Dimension timbers shown in section are not cross hatched by some draftsmen but they use a convention of crossing diagonal lines instead, as is used in this drawing for the plates and sills. The siding, sheathing, flooring, and other thin parts are not cross hatched as they are so thin on the drawing as to make a cross hatching impractical. Where the sections are drawn to a larger scale these parts are usually cross hatched by careful draftsmen.

Note that the cross hatching across the brickwork shows that the brickwork is cut by the section. This shows that the house rests on a brick wall and not on brick piers.

Sections are a very important part of many working drawings and it is important that he who must read drawing should thoroly understand them. Nothing will make them clearer than to remember that cross hatch lines represent scratches made by the imaginary saw. He must also learn to know on what line the section is cut.

QUESTIONS AND PROBLEMS.

1. What is the principal information to be gotten from the top view of the Wrench which is not sufficiently given by the front view and the sections?
2. What are the over all dimensions of the Packing Gland?
3. How many pieces of metal is the Packing Gland made of?
4. What do the 4 concentric circles in the center of the plan (top view) of the Pillow Block Bearing represent?
5. Are the 4 bolt holes in the Bearing threaded? The bolt holes in the Packing Gland?
6. What holds the Set Collar in place on the shaft?
7. How many pieces of boards make up the shaft or central part of the Porch Column?
8. What kind of joint is used in fastening these together, butt or miter?
9. How thick is the Swing Board?
10. How many pieces make up the Tie Ring?
11. A prominent line has been omitted on this drawing. What is it?
12. What size timbers are used for rafters in Section of Wall?
13. How long are the wall studs?
14. What information do we have as to the shape of the barrel through which the screw in the "C" Clamp goes which shows that it is round and not square?
15. Draw a two view detail of the barrel of the "C" Clamp as it would appear were it square. Break the barrel off so as to save drawing the entire clamp frame.
16. Make a full size detail drawing of each piece of the Tie Ring using all necessary views or sections to fully show each part. Dimension fully each part.
17. Make a full sized drawing of the Packing Gland using three views. Make the front view a combined section and front view like the front view of the Pillow Block Bearing.
18. Draw the Wrench using an end view and a top view. Place a revolved section in the handle part and an inserted section in the central portion.
19. Draw the Newel using top view, front view and a sectional side view.

IX. BOLTS, SCREW THREADS, MACHINING OR FINISH

Bolts and nuts are not difficult to recognize on a drawing but are easily mistaken as to kind. Bolt heads and nuts are ordinarily either hexagonal or square. These are shown in Figs. 1 and 2, Plate VIII. It is not difficult to distinguish between the square and hexagonal nuts or bolt heads in top views but side views are sometimes confusing when a corner rather than flat face is represented as being toward the reader, as is the case in the front view of Fig. 1 and the auxiliary view of Fig. 2.

Note the conventionalized method of representing the screw threads in these two figures. Note that these lines are not drawn exactly at right angles with the axles of the bolts though occasionally they are so represented by draftsmen, as in Fig. 4. The advantage of showing them with a slight pitch is that it gives the draftsman a chance to differentiate between a right hand and a left hand thread. A little thought will make it clear that the nuts on these two bolts would be turned clockwise in being screwed on to the bolts. The threads are therefore right hand threads. Note that the threads on the bolt end shown in Fig. 3 are slanting opposite from those in Figs. 1 and 2 so these threads are clearly left hand threads. Where draftsmen draw these threads perpendicular to the axis of the bolt the reader can safely assume that they represent right hand threads unless an accompanying note specifically indicates otherwise.

Figs. 4, 5, 6 and 7 indicate other common screw thread conventions. Fig. 8 shows five holes tapped with screw threads—*A* being shown with a stud in it. Note the top views of these holes. Note that the dotted line representing the bottom of the screw threads in the plan of A is differently placed from that of B and C. This placing of the dotted line makes clear the difference in top views between a stud and a tapped hole. In the top view of D the dotted circle is replaced by an arc of a circle. Though probably not as much used as a fully dotted circle it should be recognized as meaning exactly the same thing. E is an example of where threaded lines are drawn horizontally and does not show the hand of the threads.

Note that the stud in A is not represented as being entirely through the hole, also that the threads on the stud are right hand threads. The reader will note that the threads in the hole below the stud are drawn at a reverse angle to those on the stud. This does not indicate that the draftsman has represented a stud having right hand threads in a hole tapped with left hand threads. If the reader will recall that the front of the hole is represented as being broken out so that he sees the back side of the hole where the angle of the threads

are the reverse of the front side, it will be clear that these threads are really right hand threads. Of course, the threads shown on the stud are those on the front side. Care must be taken in reading screw threads as represented in sections or breaks to keep in mind this matter or the reader will interpret them as being wrong hand.

Where screw threads are shown by dotted lines as in "C" they are either drawn perpendicular to the axis of the hole or at the proper angle for the side of the hole nearest the reader.

Because it is so easy to misinterpret the hand of screw threads and because most threads are made right hand anyway, it is usually safe to call all threads right hand unless specifically indicated by a note as otherwise or the construction obviously demands a left hand thread.

In machine shop work the filing, turning or otherwise smoothing up of rough iron is known as Finish. The note accompanying the drawings of Figs. 1 and 2 "Finish all over," indicates that these bolts are to be finished on all surfaces. The small italic *f's* drawn across the boundary lines of the rectangular piece, Fig. 8, indicate that these faces are to be finished or machined. Occasionally, draftsmen use the words "turn," "plane," "face," etc., instead of the word, "finish or the letter *f*.

Finish is indicated in Figs. 3 and 6, Plate V. In Fig. 6 the word "turn" is used to show that the piece is to be turned down to the stated size. In this drawing the draftsman has departed from the more usual custom of using a small *f* by using a capital *F*.

QUESTIONS AND PROBLEMS.

1. Are the threads right or left hand in the Connecting Rod End Plate VI?
2. How are the threads of the Clamp Lever, Plate VI, to be made, by chasing or by tapping?
3. If this piece were turned over to you to thread would you thread it right or left hand?
4. Are the square threads in the Lathe Tail Stock Spindle, Plate VI, right or left hand?
5. What screw threads do you find on Plate VII?
6. Copy Fig. 10, Plate IV, at an enlarged scale and show the four holes in the end as being tapped for threads.
7. Make a sketch of the Lathe Faceplate, Fig. 7, Plate III, but represent it in section and with the large hole properly threaded. Indicate properly on your sketch such surfaces as should be machined.

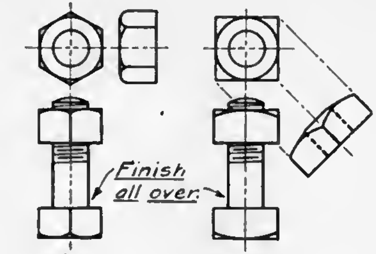


Fig. 1 Fig. 2

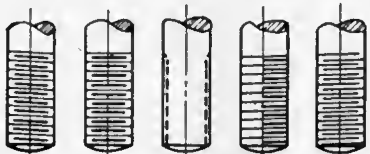
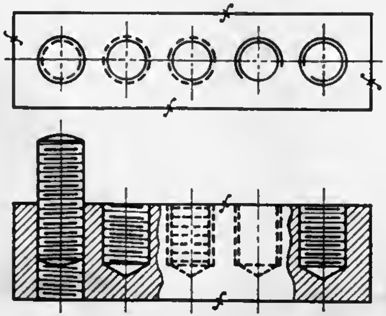
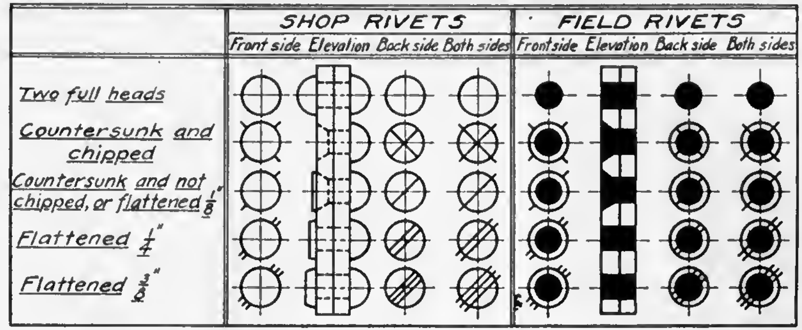


Fig. 3 Fig. 4 Fig. 5 Fig. 6 Fig. 7

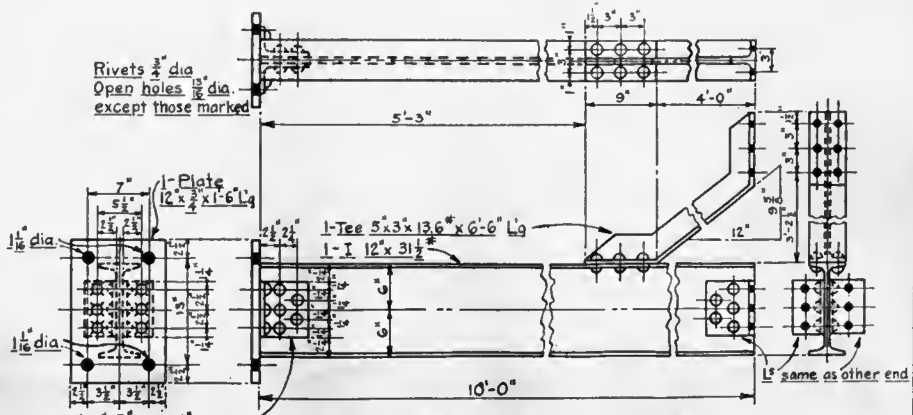


A B C D E

Fig. 8



RIVET SYMBOLS



STRUCTURAL STEEL MEMBER

X. RIVETS—STRUCTURAL STEEL

Structural steel drafting is so influenced by the character of the material drawn that it will be well to give a little special study to it.

Rivets which are drawn on ordinary machine drawings are ordinarily drawn strictly in accordance with the rules of projections and anyone familiar with working drawings can interpret the kind of rivet indicated if he never saw a rivet. On structural steel work, rivets form such an important part of almost every drawing that draftsmen have adopted a very conventionalized set of symbols for representing rivets. A chart of these rivet symbols is shown on Plate VIII. It should be carefully studied.

Note that this chart divides rivets into two classes, Shop Rivets and Field Rivets. Shop rivets are such rivets as are put in in building up the parts in the shop while field rivets are put in on the job. The holes are drilled and if the drawing calls for it, countersunk in the shop for field rivets. Field rivets are always represented in solid even in elevation.

Plain rivets button head on both ends, are indicated in end views by a small circle the size of the rivet head. If it is to represent a hole for a field rivet, it is drawn the size of the rivet shank and filled in solid.

Countersunk rivets are indicated by crossing lines. If the countersunk end is toward the reader, the crossing lines are only shown without the circle, if countersunk on the side away from the reader the cross is within the circle, if the rivet is to be countersunk on both ends, the crossing lines are indicated both within and without the circle.

The height to which rivets are to be flattened is indicated on the end views by a single line across the center of the circle for those flattened 1/8″ high, two parallel lines for 2/8″ high and three lines for 3/8″ high. These lines conform to the same arrangement regarding the circle as those indicating the countersink—appearing outside the circle only for the end toward the reader, inside for the end away from the reader, both outside and inside for both ends.

Where bolts are shown on structural steel work they are ordinarily conventionalized to the extent of omitting the threads. This is because they are ordinarily standard stock machine bolts.

The necessity of showing the dimensions of rivets and rivet holes is usually dispensed with by the use of notes. The dimension and weight per foot of standard structural steel members as I-beams, channels, tees, etc., is usually indicated by a note on or alongside the member rather than by dimension lines. The mark # used with such notations indicating pounds. See Structural Steel Member, Plate VIII.

The crowded space for dimensioning of rivet spacing and other close parts on structural work has led structural steel draftsmen to adopt the method of placing the dimensioning numeral above a continuous dimension line instead of in a break in a broken dimension line as is universal with other draftsmen. This is done even where space would permit of the more general practice.

Angles are never indicated by degrees as in machine work but are indicated by their tangents on a 12″ base lines. This is the way the bends on the tee brace on the drawing Structural Steel Member are indicated, as the reader will note.

The reader will do well to give considerable study to this drawing; note that the cross section shape, over all dimensions and weight of the various parts per linear foot are given by notes. The dimension lines are principally for locating rivet holes. The various kinds of rivets are indicated by proper rivet symbols. The draftsman has utilized the privilege of breaking his drawing in order to accommodate it to the space available on the drawing sheet.

QUESTIONS AND PROBLEMS.

1. What size rivets are used in the Structural Steel Member, Plate VIII?
2. How many steel parts in this assembly?
3. How long a piece is required for the brace piece?
4. How much will the entire I-beam weigh? The Tee brace?
5. What size are the angle pieces on the right hand end?
6. Where are counter sunk rivets used on this construction?
   Are they chipped flush with the surface or left rough?
   Which face is the countersinking on?
7. What kind of rivets are to be used in riveting on the construction at the outer end of the brace?
   What size holes are these rivets to go into?

XI. ARCHITECTURAL CONVENTIONS

The student of drawings will find considerable difference between the drawings made by architects and those made by mechanical engineers. The architect goes less into detail, as a rule, than the engineer, leaving details more largely to the workman. He does not dimension his drawings always as fully as is needed by the man who is to use them. As a result architectural drawings require more scalings than machine drawings. The architect will stress the matter of appearance of what he is designing more than will the average engineer. Architects use a greater number of conventions than mechanical engineers. An engineer uses few conventions for the parts he draws, he draws everything out strictly in accord with the rules of projection. He slightly conventionalizes screw threads because they are small and hard to draw accurately, but the architect abbreviates his work by a great many conventional representations.

In architectural drawings the terms plans and elevations are used in place of the terms views or projections. The term plan is used in place of top view or horizontal projection. A roof plan is a top view of a building, a floor plan is a top view of a floor with the walls cut off about half way from the floor to the ceiling—in other words a floor plan is a horizontal section of a building looking downwards. Elevations are front or side views, and are often designated as north, south, east or west elevations as the case may be.

Walls of frame buildings are conventionalized on floor plans by two parallel lines spaced at a distance apart equal to the thickness of the walls—usually 6″ or 8″. See the adjacent wall represented in the first few examples of windows and doors, Plate IX. When masonry walls are shown on a floor plan the lines are usually filled in between with cross hatching. See example of Two Sash Masonry Wall Window and Basement Single Sash Window, Plate IX. Occasionally an architect fills in solid between the wall lines with a brush or pencil instead of with cross hatching. Where floor plans are to be printed in books and magazines often the walls are filled in solid for frame buildings as well as for masonry buildings as they show up better, but this is rarely if ever done on blueprints.

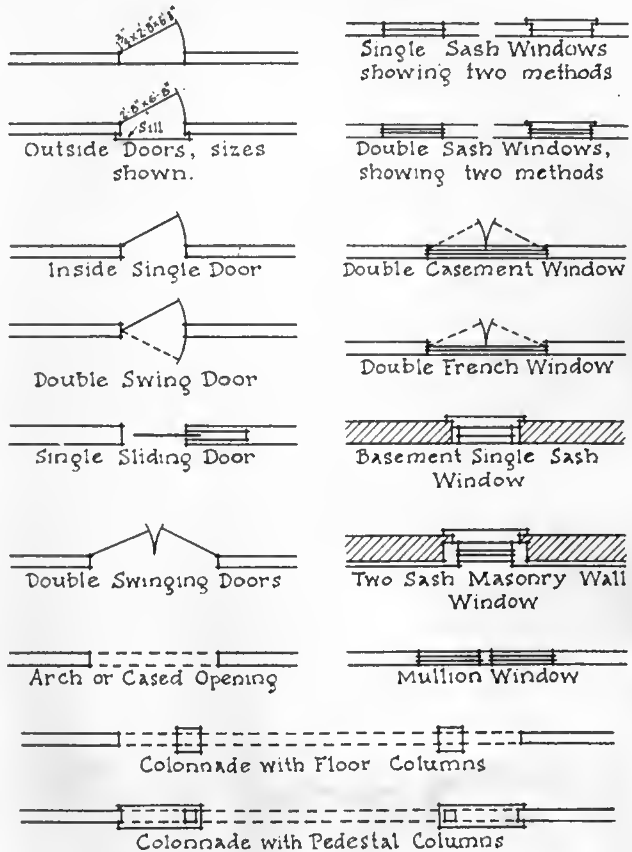
Doors are usually shown as single lines. They are always represented as more or less open. The arcs shown in the example on Plate IX, are often drawn dotted.

Windows are sometimes drawn with one line representing a sash and sometimes with two so that it is not always certain whether a double line represents

GAS AND ELECTRIC SYMBOLS

Telephone, private service.
Telephone, public service
Bell Outlet
Buzzer Outlet.
Push Button Outlet, numeral indicates number of pushes.
Annunciator, numeral indicates number of points.
Speaking Tube
Door Opener
Electric Ceiling Outlet, 2 lights.
Electric and Gas Ceiling Outlet, 2 each
Gas Ceiling Outlet, 2 lights.
Electric Wall Outlet, 2 lights.
Electric and Gas Wall Outlet, 4 electric and 2 gas lights.
Gas Wall Outlet, 2 lights
Electric Wall or Baseboard Receptacle Outlet.
Electric Floor Outlet, 4 lights
Electric Drop Cord.
Special Outlet for lighting, heating and power current as described in specification.
Ceiling Fan Outlet.
•S'IV Four Single Pole Switches
•S⁴ Switch, 4 way.
Distribution Panel
Motor Outlet, numeral indicates horsepower.
Motor Control Outlet
Rheostat
Variable Resistance
Inductive Resistance.
Crossing Wires
Joined Wires
Ground
Transformer

ARCHITECTURAL FLOOR PLAN CONVENTIONS WINDOWS AND DOORS



a single or double sash window. The line representing the sill edge is not always shown on frame building plans but always shown on plans for masonry buildings.

Dotted lines on a floor plan do not always represent something hidden under the floor, but usually represent something above. Note the dotted lines apart of the conventional representations of the Arched or Cased Opening and the examples for colonnades. These dotted lines represent that part of the wall extending over the openings. The drawing Plan of Small Building, Plate X shows where the draftsman has differentiated between lines representing that which is above and that which is below the floor by using plain broken lines for one and dot and dash lines for the other.

Note in the chimney examples how a tile lined chimney is shown. Where building laws require chimneys to be lined or the matter is covered in the specifications this is not always drawn in. Some architects state the size of the flue opening by figures arranged thus, 8/8, 8/12, as the case may be, placed in the center of the chimney drawing.

Lines similar to those showing the lining of the chimney appear on the inside of the wall drawing, Two Sash Masonry Wall Window, Plate X. These show that this wall is either sheathed or plastered up on the inside. Note that it is not so shown on the drawing Basement Single Sash Window.

Fireplace drawings on floor plans do not show the flue to the fireplace but may show flues coming up from the basement or story below along with the masonry of the fireplace. Neither these flues nor ash dumps must be interpreted as flues to the fireplace. The flue to the fireplace will appear only in the plan of the floor or roof above.

Plumbing conventions are usually pictorial enough to readily be recognized, but gas and electrical conventions are not quite so easy to understand and should be carefully studied.

Stairs are readily recognized but it is not always clear whether the stairs go up or down from the floor. The cue is in the arrow with its accompanying word Up or Down—sometimes abbreviated *U* or *D*. Remember the arrow leads from the floor, the plan of which you are reading. Do not imagine that an arrow marked down could be reversed in direction and marked up and mean the same thing. In the first case the stair, if in a one story house, would lead to the basement and in the second case lead to the attic.

Where pipe is shown in large enough scale, as in detail drawings, pipes are shown by two parallel lines,

ARCHITECTURAL FLOOR PLAN CONVENTIONS
STAIRS, CHIMNEYS FIREPLACES & PLUMBING FIXTURES

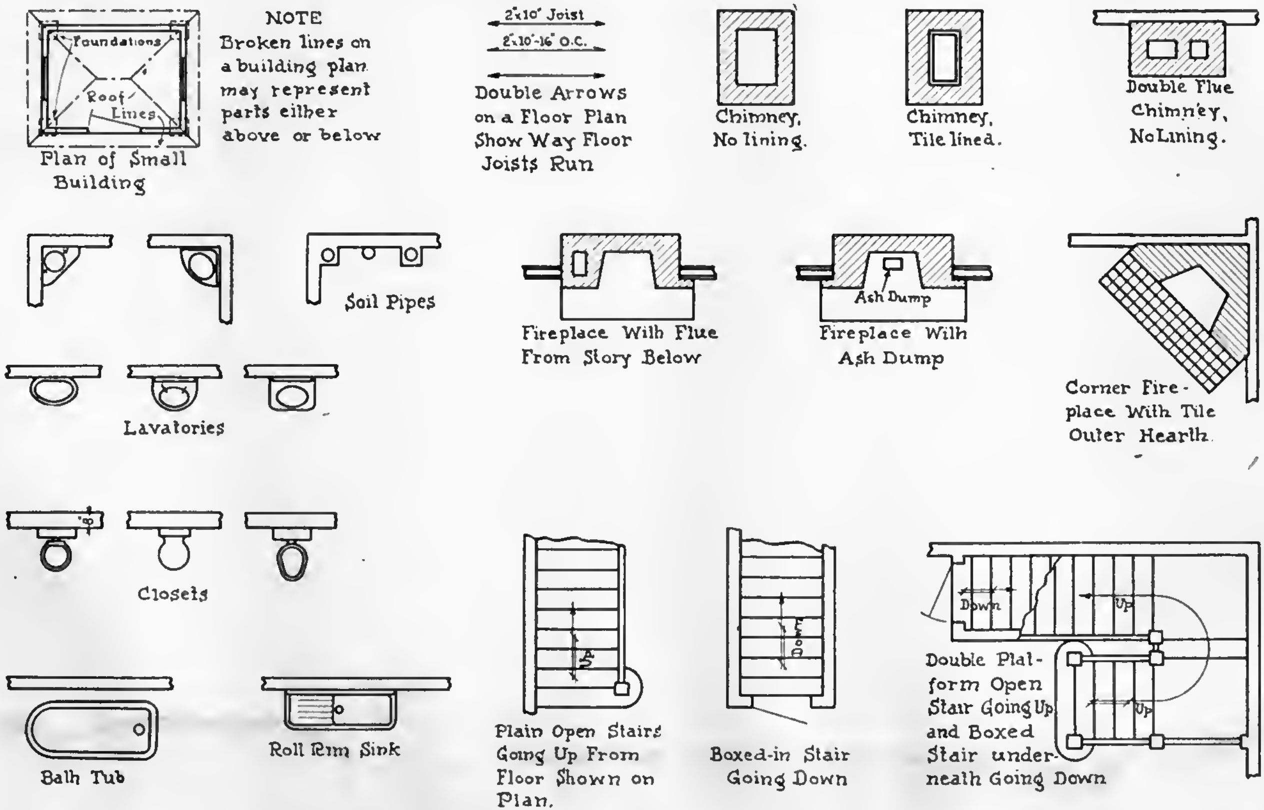


Plate X

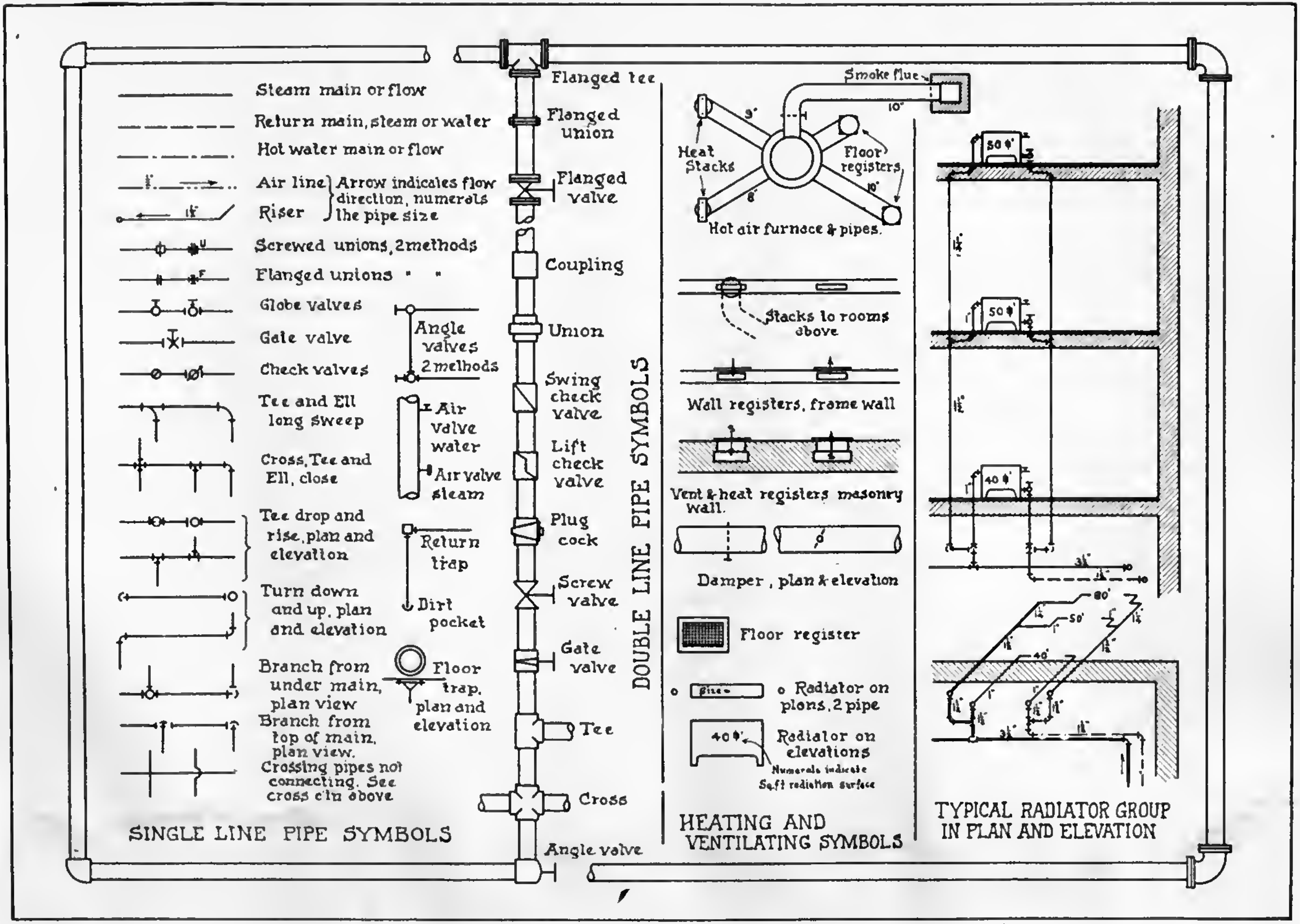
as the pipe border about Plate XI. Where pipe and scale are large enough the pipe fittings are more or less accurately drawn true to projection but as these are reduced to smaller size on drawings, draftsmen more or less conventionalize the drawings of these fittings. They are usually near enough like the true projections as to be readily recognized by one familiar with pipe fittings. A study of the Double Line Pipe Symbols shown on this plate will make it clear that the more common fittings can easily be memorized. Draftsmen usually mark by a note any unusual fittings. Note that flanges are always plainly indicated on flange fittings.

It should be understood that these symbols are not universally used by draftsmen, but there is not variation enough but that if one is familiar with these he will find little confusion from reading the drawings of different draftsmen. It is like reading the handwriting of various persons. Each writer has his individual style but even a poor reader can read the writing of any good penman.

Where the scale is small draftsmen use the Single Line Symbols shown on the left side of the plate. Even where the scale is large enough so that double line pipe symbols could be used, draftsmen very often use the single line symbols because of its simplicity. In this system the fittings are much more conventionalized than in the double system.

Ordinarily the solid line is used to represent a pipe but where it is desired to differentiate between the flow and return lines a broken line is used for the return. The direction of flow of the water or stream is indicated by an arrow. The inside diameters of the pipes are indicated by numerals placed alongside. Note that several fittings have more than one way of being represented. There are still other variations used by some draftsmen but if the reader is familiar with these shown, variations will not be confusing. Note the difference between the representation of a plan of the tee drop and a tee rise also the plan representation of a turn up and a turn down.

The Typical Radiator Group shown both in plan and elevation on the right of the plate illustrates well how these symbols appear in use. Note that if you are familiar with the meaning of the various symbols you can get the same information from either plan or elevation. Probably the only thing that cannot be told from one and not the other is the lengths of some of the numerous pipes. In practice a draftsman would ordinarily furnish but one drawing either a plan or an elevation.



Steam main or flow
Return main, steam or water
Hot water main or flow
Air line
Riser
Arrow indicates flow direction, numerals the pipe size
Screwed unions, 2 methods
Flanged unions
Globe valves
Gate valve
Check valves
Angle valves 2 methods
Tee and Ell long sweep
Cross, Tee and Ell, close
Air valve water
Air valve steam
Tee drop and rise, plan and elevation
Return trap
Turn down and up, plan and elevation
Dirt pocket
Branch from under main, plan view
Floor trap, plan and elevation
Branch from top of main, plan view.
Crossing pipes not connecting. See cross c'ln above
SINGLE LINE PIPE SYMBOLS
Flanged tee
Flanged union
Flanged valve
Coupling
Union
Swing check valve
Lift check valve
Plug cock
Screw valve
Gate valve
Tee
Cross
Angle valve
DOUBLE LINE PIPE SYMBOLS
Smoke flue
Heat Stacks
Floor registers
Hot air furnace & pipes.
Stacks to rooms above
Wall registers, frame wall
Vent & heat registers masonry wall.
Damper, plan & elevation
Floor register
Radiator on plans, 2 pipe
Radiator on elevations
Numerals indicate Sq.ft radiation surface
HEATING AND VENTILATING SYMBOLS
TYPICAL RADIATOR GROUP IN PLAN AND ELEVATION

Plate XI

For the sake of study we will follow the pipe, using the plan drawing only, from its beginning at the lower right corner until its return. The student will do well to follow the line with a pencil point as he reads.

The first fitting we encounter is an ell by means of which the pipe turns to the left. As we follow the line to the left we pick up the dimensions of the pipe, learning that it is a 3½″ pipe. The next symbol is one showing a branch from the top of the main we have been following. There is nothing to show how much this branch rises before it branches off. That can only be read by referring to the elevation drawing. Following this branch we discover that the branch is smaller than the main, being but 1½″. A tee separates the line. Following each branch, past an ell in one, we reach symbols indicating risers. Extending backward and to the right from these risers we find fine lines which represent the risers as though they stood up from the surface of the paper and were leaning out of the way of our view of the rest of the drawing. Note that the terminal of each branch from the flow riser is a numeral, indicating the number of square feet of radiating surface that the radiator there is to have. On following the return branches and return riser back we note that these return pipes are the same size as the flow pipes. When the return reaches the point where it distinctly becomes a return main the draftsman uses the return main symbol of a broken line.

At the upper central part of the plate is shown a hot air furnace and pipes as they would appear on a basement plan. If these were shown on the first floor plan as they occasionally are, they would be drawn with dotted lines to indicate that they were hidden beneath the floor. Note the difference between the floor registers and the stacks. The pipes terminating in floor registers would supply heat to the first floor rooms, while the stacks would carry heat to the second story rooms.

The arrows on Heat and Ventilation Registers indicate the direction of air flow and consequently whether the register is to supply heat and fresh air or to carry off foul and cold air.

The Floor Register is drawn thus on floor plans only.

Radiators are sometimes drawn more elaborately than here shown but their position usually makes clear what they are. On plans they are often inked in solid and usually have the abbreviation Rad. printed on them. The numerals on the elevation indicate the number of square feet of radiating surface the radiator is to have.

QUESTIONS AND PROBLEMS.

1. Are windows single or double sash in Plan of Small Buildings, Plate X?
2. What kind of windows are indicated in the House Plan on Plate V?
3. Is the chimney of this house to be lined?
4. What valves do the radiators in the Typical Radiator Group Plate X have? Can this be determined from the plan view?
5. Why was it unnecessary for the draftsman to show by arrows the direction of flow of the steam in the pipes for this group?
6. Are all the radiators of the Typical Radiator Group of the same size?
7. Are the flow and return mains the same size?
8. Make an enlarged sketch of the kitchen from the house plan in Plate V and locate a hot water heater in the corner by the chimney and a kitchen sink by one of the windows then connect the two by necessary pipe. Conceal pipe in the walls and under the floor. Use single line conventions and draw in all necessary symbols.
9. Sketch both plan and elevation of a water system consisting of a storage tank on a low tower, a line coming from a pump house, a line running to a yard hydrant and one to a residence. Show all necessary pipe fittings by single line symbols.
10. The owner of the house shown on Plate V wishes to remodel it by building a wing and a second story over the old part and by placing a furnace basement under the old part. Make a sketch of a basement plan and lay out a hot air furnace heating plan showing furnace heating, pipes, registers, stacks to second floor rooms, etc.
11. Lay out necessary piping to run a hot water line from the furnace to the kitchen and to a bathroom to be located on the second story directly over the two closets shown on the plan. You use single line system.

XII. STUDY OF A SET OF HOUSE PLANS

The use of the word plans in the title to this chapter is in accord with the quite common usage of calling all of a set of architectural drawings plans regardless of the fact that the set may be composed of many drawings which are not plans but are elevations or detail drawings. In this case the set consists of Front Elevation, Side Elevation, Floor Plan, Roof and Attic Plan, Basement Plan, Masonry Details, and Cabinet Details—Plates XII to XVIII.

Not all of the information needed by a workman on the building can be secured from the drawings. Such drawings are always accompanied by a set of written specifications which specify such matters as kind and quality of materials to be used, methods of workmanship, etc., which can not be shown on the drawings. As this work is on the study of drawings and not specifications mention of specifications is made simply that attention may be called to the fact that drawings and specifications should ordinarily be studied together.

The study of a set of drawings can not advantageously be studied as the specifications can by beginning with the first sheet and reading the set through one sheet after another. Instead we look the entire set through to get the main characteristics of the building in mind and then by referring back and forth from sheet to sheet we study out detail after detail until all the details of construction are in mind.

Perhaps the term plans is used so commonly to include all the drawings of a set because most of the dimensions and detailed information is found on the floor plans. However, the general type of the structure is usually more clearly shown by the elevations. For this reason we will look over the elevations first in this study, but not give them a very thorough study until we have looked through the entire set. If the student has not already done so, he should pause here in his reading and spend a few minutes looking over the drawings of the Residence—Plates XII to XVIII.

This preliminary study of the entire set should have told the student that it is a complete set of working drawings of a story and a half frame residence, having as prominent characteristics, a large front porch with brick buttresses to the columns, a three gable roof, a small ornamental shed dormer window on the roof, an outside fireplace, a screened back porch, five rooms on the main floor—living room, dining room, two bedrooms and a kitchen—, a basement with hot air heating system, a servants' room and a large storeroom on the second floor, and built in buffet and colonnade book case.

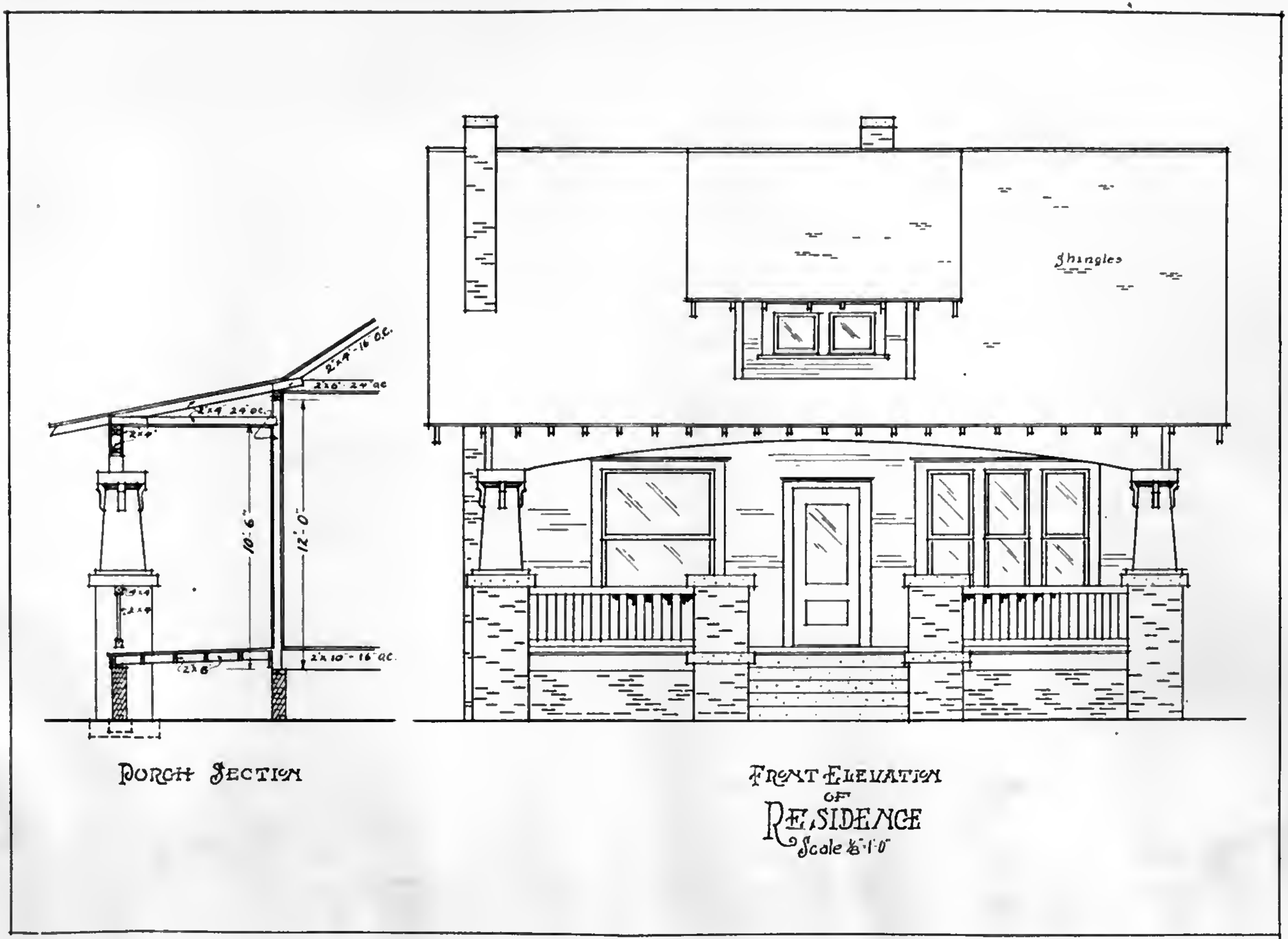

2"x4"-16" o.c.
2"x6"-24" o.c.
10'-6"
12'-0"
2"x10"-16" o.c.
Shingles
Porch Section
Front Elevation
of
Residence
Scale 1/8"=1'-0"

Plate XII

Probably also he will have picked up such details as, that the front porch steps are of concrete, that there are louvres in the gables, that exposed rafter cornice is to be used, that the dining room is to have beamed ceilings, that there is a bath room with three fixtures in it, that the basement stairs are directly under the second story stairs, that the furnace room does not extend under the entire house, that only part of the second story is floored, that the porch buttresses are hollow, that both brick and concrete is used in the foundation walls, and many other similar pieces of information.

If the student will turn his attention to the front elevation, Plate XII, the author will try to lead him in a more thorough study of this drawing. Note that the house rests on a brick foundation but that the fine dots covering the steps show that the steps are to be of concrete. There are four brick column piers but not all of them support columns. These piers are capped by concrete caps. The horizontal sketchy lines on the front face of the building show it to be of wood siding and not of plaster or stucco. The few scattered shingles drawn on the roof as well as the word "Shingles" shows the character of the roofing material.

The exposed rafter ends along the front of the porch roof show that an open rafter cornice is to be used. The student will make a mental note of the character of the windows, front door, porch rail and other details.

The student should study the Porch Section along with the Front Elevation. Such sections are drawn by draftsmen before drawing the elevations. These sections establish heights of floors, ceilings, cornice, and many other details.

Perhaps a study of this section will give the student his first information that the porch roof is not the same pitch as that of the main roof. It is the only source on the entire set of drawings from which he can learn the porch ceiling height.

Many important details of construction are to be learned from this section—size and spacing of studs, rafters, joists, etc., are all important construction details.

When the student turns to the study of the Side Elevation, Plate XIII, he secures additional information regarding the shape of the roof. He learns that the house is larger from front to rear than from side to side. He notes that the windows are grouped in threes as a rule but finds no figures to indicate their size. Two single light windows near the rear show hidden edge lines extending up over them. He will likely understand these lines to indicate pockets in the


SIDE ELEVATION
OF
RESIDENCE
Scale 1/8"-1'0"

wall for the windows to slide up into showing that they are jib windows.

In studying the front porch the student will note something which may have escaped him in his study of the front elevation that brick buttresses extend out alongside of the front steps.

A little study of the rear of the house shows a screened porch and a flight of back steps evidently of wood construction.

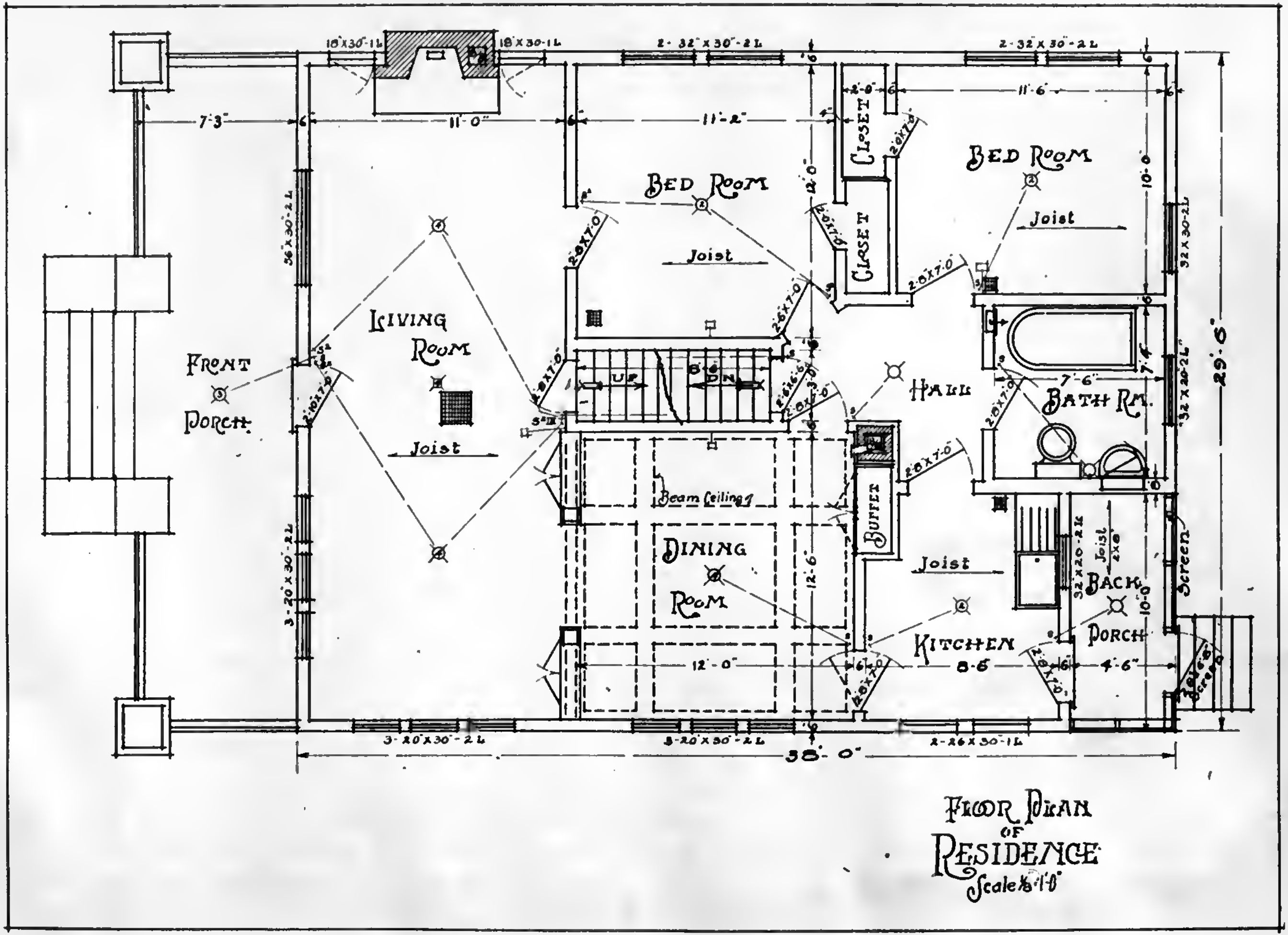
When the student turns his attention to the Floor Plan, Plate XIV, he may find it such a maze of lines as to require considerable study to make these lines convey a definite meaning to him. Picking out the names of the rooms, referring back to the elevations and to the plates of architectural conventions in the next preceding chapter all will help to make these lines stand for definite walls, doors, windows, fixtures, etc.

When he examines the front porch he will doubtless note that the masonry buttresses at the corners of the porch are represented differently from the two central ones. Reference to the elevations will make it clear why they are not alike. Notes by the front windows show the size of glass in these windows and that all are two light windows. The fact that these windows are shown by two lines instead of one shows that they are double hung—two sash—windows. The student should study all the windows and note their size, number of sashes, method of hanging, etc.

The note by the front door shows its size. The student should note whether the other doors are all this size. He should discover whether or not any are double acting and if there are any cased openings having no doors.

Near the center of the Living Room the student will note a double end arrow indicating the direction the floor joists are to run. Study of similar arrows in other parts of the house will show that there is one place where the joists change direction. If he will refer back to the Porch Section he will find another place where the direction is out of the general arrangement though no arrows indicate it on the floor plan.

The student should study the electrical symbols in the various rooms. Two electric ceiling outlets are shown in the Living Room each to be wired for four lights. Outlets in other rooms are to be wired for a various number of lights. In one room he will find a wall outlet instead of a ceiling outlet. He must not mistake the wall plugs shown in three or four rooms for wall light outlets nor the floor plug in one room for a ceiling outlet. He should locate the switches to the



FLOOR PLAN OF RESIDENCE
Scale 1/8"-1'-0"
LIVING ROOM
FRONT PORCH
BED ROOM
BED ROOM
CLOSET
CLOSET
HALL
BATH RM.
DINING ROOM
BUFFET
KITCHEN
BACK PORCH
Beam Ceiling
Joist
Screen
38'-0"
25'-6"

Plate XIV

various lights and note if any lights are drop lights. He will note that by the front door are two two way switches controlling the porch light. At the opposite side of the room he will find that Roman numerals indicate three two way switches. One of these two way switches sharing with similar switches on the opposite wall in controling the Living Room lights. At the opposite side of the room he will find that Roman numerals indicate three two way switches. One of these two way switches seems to control a light up stairs since the connecting wire is shown running up the stairs and stopping at the freehand line indicating a breaking off of the stairs. The student should pick this line up when examining the upstairs and locate the light it controls.

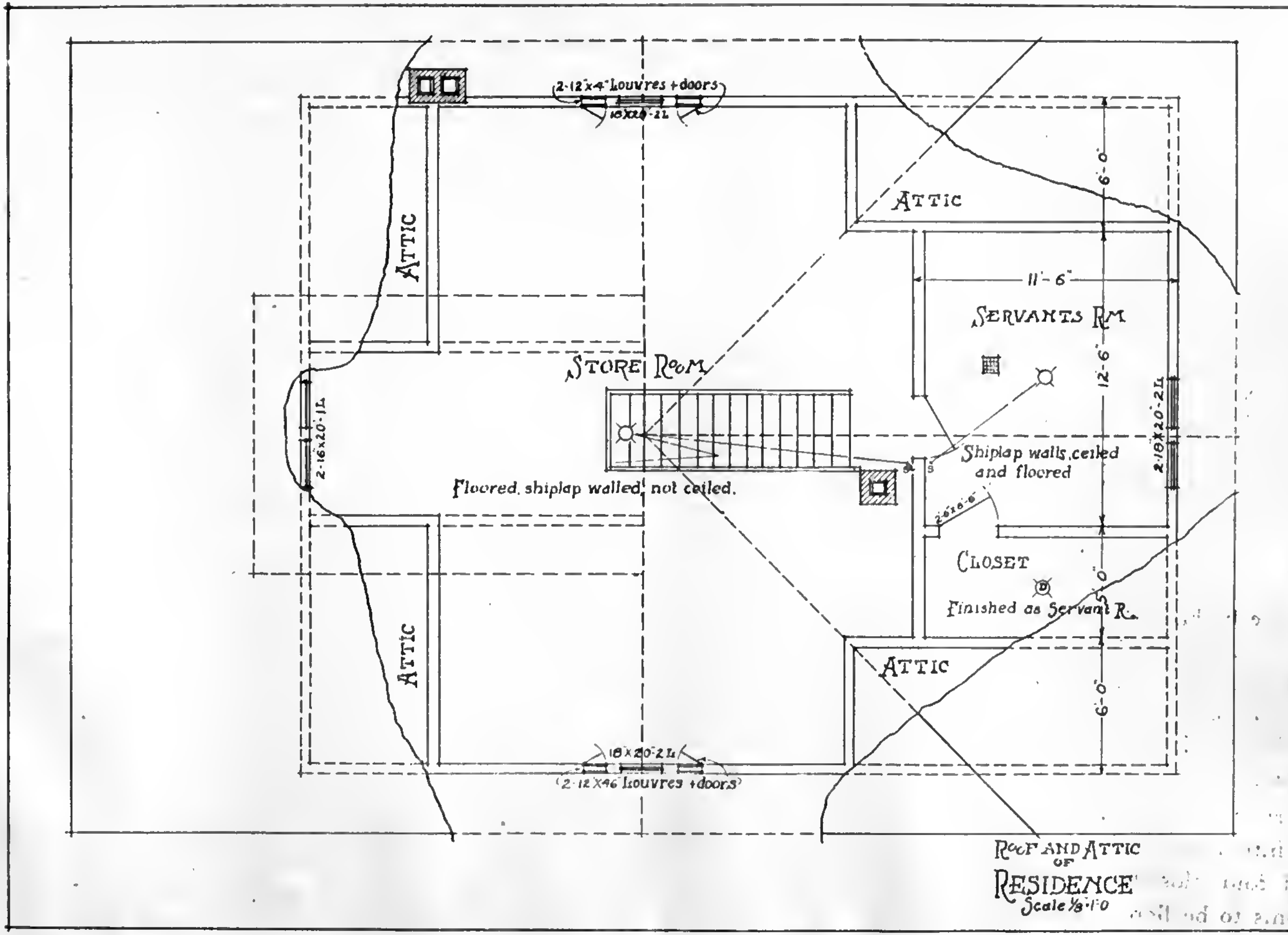
He should examine the stair carefully as these are frequently a cause of confusion and mistaken ideas to an inexperienced reader of drawings. The break line drawn across the stair space and the two arrows one marked "Up" and one "Down" shows that the draftsman has indicated that two stairs are to occupy the stair well one going up from the main floor and one underneath going down from the same floor. It is usually well in reading stairs to confirm one's reading by a study of the representation of the stairs on the plans of floors above and below. The student will therefore do well to look back to the Basement and Attic Plans.

The student will discover by the note "Beam Ceilings" explanation of the numerous dotted lines in the Dining Room. The student should locate the buffet opening into the dining room, the back chimney noting into which room the thimble opens, the kitchen sink and draining board, the bath room fixtures.

In the Bath Room he should notice that there is a medicine closet built into the 8″ wall and that the heat register opens from the wall rather than through the floor as indicated in most of the rooms.

The student should study the dimensions of the various rooms noting carefully whether the dimensions read from the inside, center or outside of the walls. If he studies the wall thickness carefully he will note that the walls are not all 6″ thick, that one is an 8″ wall and some are less than 6″.

While studying the floor plan the student will do well to turn back to the drawing of Cabinet Details, Plate XVIII. In the study of these details he will get his first intimation that the Dining Room is to have a plate rail and to have paneled walls below the rail. Here he will get minute details of such parts as will likely be made in a cabinet works and built into the house. The student should figure out the number of



2-12"x4" Louvres + doors
16x20-2L
ATTIC
ATTIC
6'-0"
11'-6"
SERVANTS RM
STORE ROOM
12'-6"
2-16x20-1L
2-18x20-2L
Shiplap walls, ceiled and floored
Floored, shiplap walled, not ceiled.
CLOSET
Finished as Servant R.
ATTIC
ATTIC
6'-0"
18x20-2L
2-12x46 Louvres + doors
ROOF AND ATTIC OF RESIDENCE
Scale 1/8"-1'0"

Plate XV

drawers, shelves, doors, etc., in each of the pieces of cabinet work details. He should note whether doors are to be glazed or paneled.

He should study the column over the bookcase to discover whether or not it is tapered and whether it is round or square. He will find the answer to both these in the dimensioning. The former by comparing the width given for the top and the bottom, and to the latter by the draftsman having used the draftsman's symbols for square in connection with the numerals.

When the student comes to studying the Roof and Attic Plan he will discover that the draftsman has started with a roof plan and then broken away all of the central part so as to show the rooms on the second floor. He has left the interfering roof lines dotted. Where he has left the roof in solid lines over the front of the house and at the rear corners, he has shown the partitions underneath in dotted lines. This double use of dotted lines may be a little confusing to the student if he does not keep definitely in mind the bounds of the broken out area.

He will note that the second floor space is divided off into a large Store Room, a Servant's Room, Closet and four closed in attic spaces. Notes indicate the rooms to be floored and walled up. Presumably since there is no instruction to floor and sheath them the attic spaces are to be left unfinished.

The student should study the windows as there are some unusual features indicated regarding them. Reference back to the Front and Side Elevations will help to understand them.

The electric light shown in the center of the Store Room is seen to be controlled by a two way switch at the head of the stairs. There is also a wire running down stairs from this light, evidently to a switch at the down stairs door to the stairs. He will find a switch controlled light in the Servant's room and a drop cord in the Closet. A floor register in the Servant's Room shows that this room is heated from the basement furnace.

The Basement Plan, Plate XVI, must be studied in conjunction with the Masonry Detail sheet, Plate XVII. The basement proper is discovered to be but one room, a furnace room with a coal bin in one end. The method of sectioning the walls shows that the Furnace Room walls are of concrete except the outside wall. The outer walls are of brick, the sectioning indicates. There are three sections cutting the furnace room walls—sections AA, BB and CC. The student must refer to these detailed sections, Plate XVII. These section details give him the depth and thickness

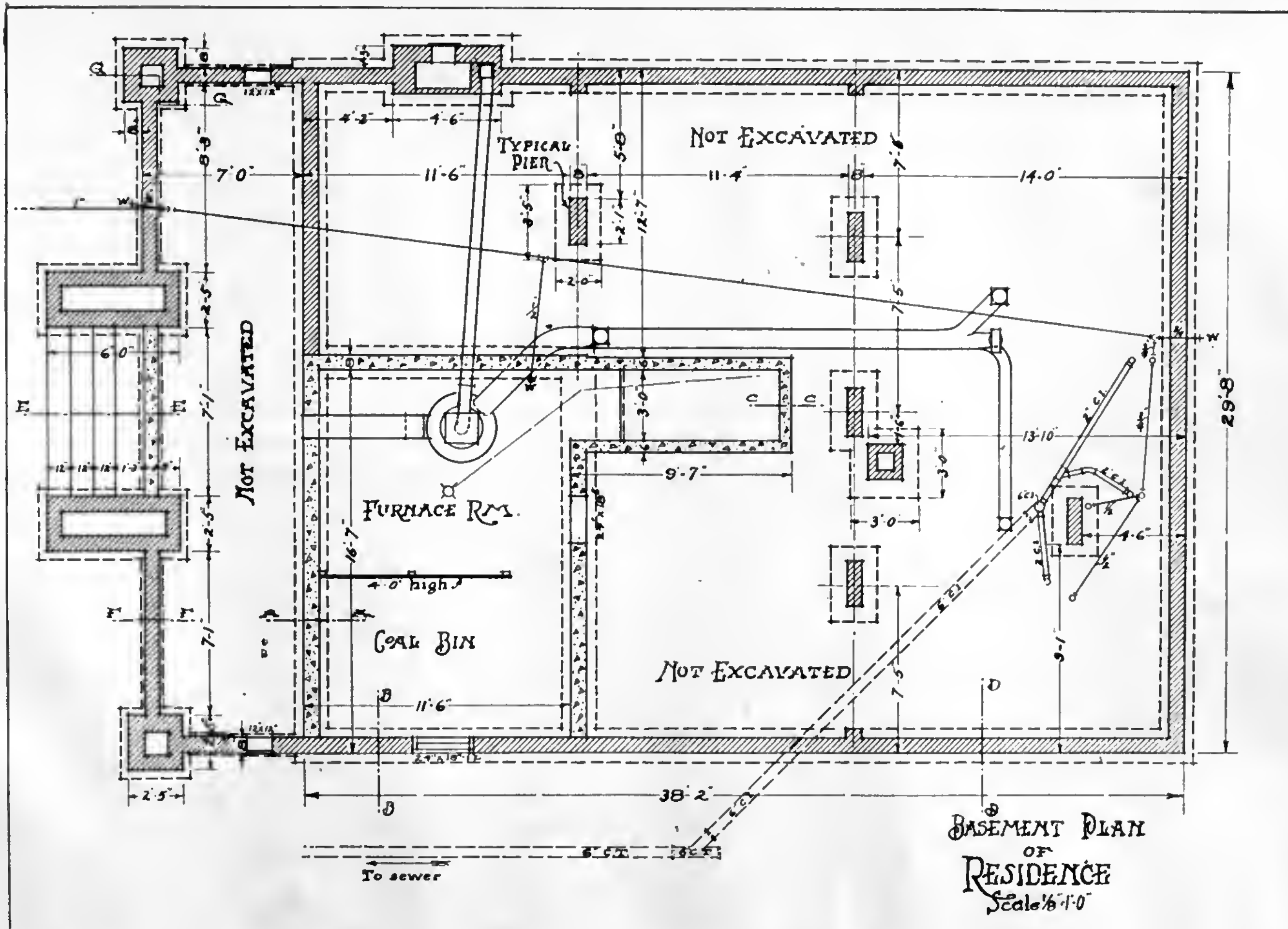

NOT EXCAVATED
TYPICAL PIER
NOT EXCAVATED
FURNACE RM.
4'-0" high
COAL BIN
NOT EXCAVATED
To sewer
BASEMENT PLAN OF RESIDENCE
Scale 1/8"-1'-0"
7'-0"
11'-6"
11'-4"
14'-0"
29'-8"
38'-2"
9'-7"
16'-7"
11'-6"
13'-10"
6'-0"

Plate XVI

of the Furnace Room walls and also causes a modification of his first impression regarding the outside furnace room wall. He discovers that this wall is brick only above the grade line. The section CC calls his attention to the fact that the stair well floor is slanting and not level with the basement floor. It also shows that the walls of the well are not the same thickness as the regular basement walls.

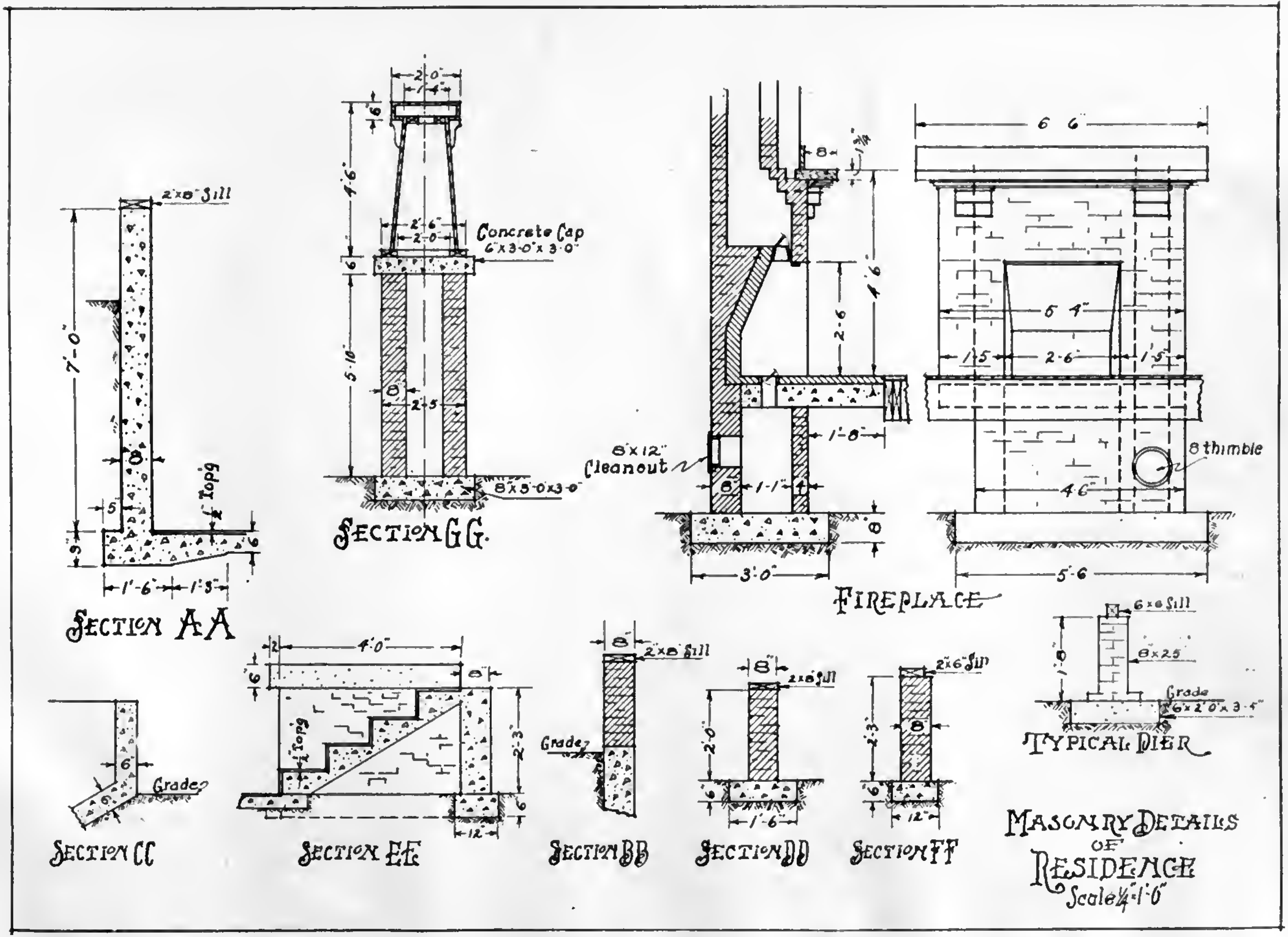
The outside wall is detailed by the Section DD, which gives the thickness and height above the foundation, the material and dimensions of the foundation, and also the size of the sill to go on the wall.

Piers are used to support such sills as have no supporting walls. Only one of these is fully dimensioned on the plan but as it is marked with the word "Typical" the student will understand that all piers are to be of the same size. The detail drawings Typical Pier, Plate XVII, furnishes such dimensions as are not given on Plate XVI. The student will note this detail is an elevation and not a cross section, even the foundation. He will discover in the size of the sills which go on these piers the explanation of why these piers are not as high as the foundation wall.

In the study of the fireplace the student will get most of his information from the detail drawing. Little is to be learned from the foundation plan except its location and the purpose of the extra flue. The extra flue is seen to serve the furnace located in the Furnace Room. The detail drawing, however, is profuse in information given. It shows all the requisite dimensions, the concrete foundation, that it is to have ash dump, clean out door, and a damper, that it is to be lined with fire brick, that the hearth is concrete underneath the brick, that the mantle shelf is of wood and many more bits of information essential to the building of the fireplace in accord with the architect's ideas.

The student should notice sections EE, FF, and GG, not only studying the details but locating them on the plan. He will observe that the line locating the section of GG, on the plan is not a straight line.

The draftsman has seen fit to show the porch column in this section though it is not a masonry detail and might for that reason have been more properly placed among the Cabinet Details. It helps, however, to illustrate a statement made in a preceding chapter that all of a set of drawings must be studied together. A mill man figuring on the mill work for this building could claim no excuse from the drawing's standpoint if he neglected to figure on the porch columns because they are not shown on the cabinet detail sheet, any more than the electrical contractor could excuse a possible overlooking of the basement light.



2"x8" Sill
7'-0"
8"
5"
1'-6"
1'-3"
Section AA
2'-0"
1'-4"
4'-6"
2'-6"
2'-0"
Concrete Cap
6"x3'-0"x3'-0"
5'-10"
2'-5"
8"x5'-0"x3'-0"
Section GG
6' 6"
8"
4'-6"
2'-6"
5' 4"
1'-5"
2'-6"
1'-5"
1'-8"
8"x12" Cleanout
1'-1"
8" thimble
4'-6"
3'-0"
5'-6"
Fireplace
6"x6" Sill
1'-8"
8"x25"
Grade
6"x2'-0"x3'-5"
Typical Pier
6"
Grade
Section CC
4'-0"
2'-3"
12"
Section EE
8"
2"x8" Sill
Grade
Section BB
2"x8" Sill
2'-0"
1'-6"
Section DD
2"x6" Sill
2'-3"
12"
Section FF
Masonry Details of Residence
Scale ¼"-1'-0"

The student should trace out the heating pipes and check them up with the registers shown on the floor plans. He will observe that there are certain rooms to which no pipes run.

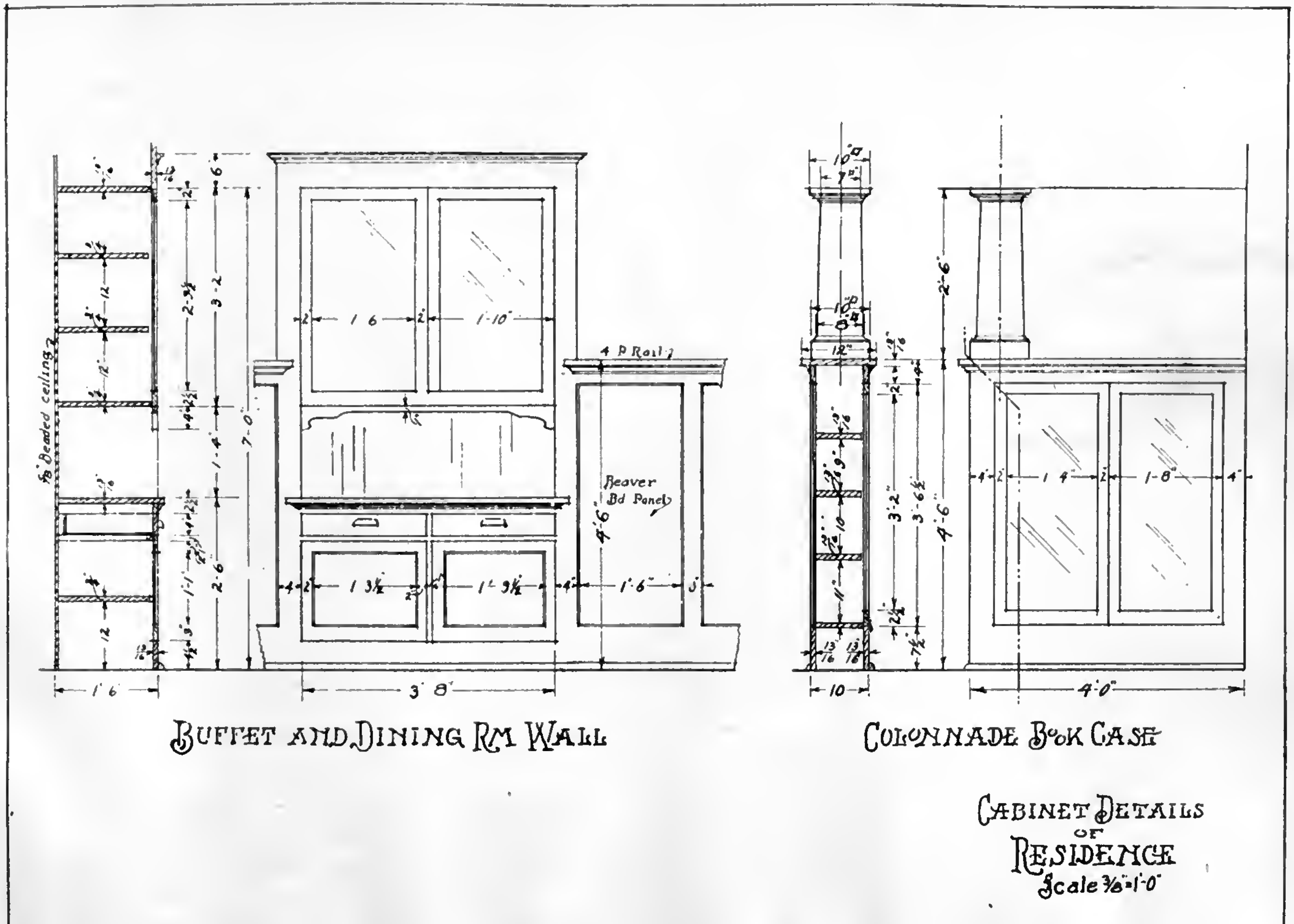
He should carefully follow the water and sewer pipes. If he will follow the water pipe as it comes under the house from the front he will note that it is 1″ in diameter, that after coming under the porch wall a ¾″ riser extends up and turns out through the wall to a hose cock. As the main passes the Furnace Room a tee takes off a ½″ pipe to supply a cock in the Furnace Room. At the rear of the building the student should continue following these pipes, possibly listing the necessary connections. He may find it necessary to refer back to Plate XI to refresh his memory regarding some of the pipe symbols.

The sewer pipes are rendered in double lines, being large enough for the draftsman to readily draw them that way. The student should differentiate between the cast iron and clay tile pipes, abbreviated C. I. and C. T.

The student will have discovered many things not mentioned above, many things that print cannot well make clear, and there will doubtless be plenty of information he can acquire by further study. He should secure sets of other building plans and study them carefully. He will find considerable individuality in the way different architects express their ideas in their drawings just as authors differ in expressing their ideas in their writing but if the student can read thoroughly the drawing of one good draftsman the individual methods of other draftsmen will cause him no trouble.

QUESTIONS.

1. Are either of the porches screened, and if so, which?
2. Of what material are the front steps to be made?
3. What do the three long wavy freehand lines on the Roof and Attic Plan indicate?
4. What is the long dashed line on the Roof and Attic Plan, which extends vertically entirely across the drawing approximately midway from right to left?
5. Are the Attic spaces to be floored?
6. How many porch columns must the mill man figure on furnishing?
7. Which way do the floor joists under the living room run?
8. Do the porch joists run the same way as the main floor joists?
9. Is there anything to indicate whether or not the ceiling joists are to run the same way as the floor joists?
10. From which room would one go in going down stairs? Up to the Store Room?
11. Is the basement window one or two light?
12. What means are provided for enabling one to get under the house to the pipes, etc.?
13. Are all windows two light and if there are any exceptions, name them?



BUFFET AND DINING RM WALL
COLONNADE BOOK CASE
CABINET DETAILS OF RESIDENCE
Scale 3/8"=1'-0"
Beaded ceiling
Beaver Bd Panel
4 P Rail

Plate XVIII

14. Are the small kitchen windows jib or casement hung? (See Side Elevation.)
15. How are the windows by the fireplace hung?
16. What distinguishes the kitchen-dining room door from all the others?
17. What doors are 6′ 6″ high?
18. Is there a plate rail in the dining room?
19. What kind of a wall separates the down stairs closets?
20. Is the wall above the colonnade opening between the living room and the dining room, the thickness of the colonnade buttress or is it the same as the other walls?
21. What length and width is the front porch floor?
22. What is the length and width of the bath room?
23. How wide is the stair well?
24. What length and width is the furnace room? Its height?
25. If the porch balusters are 24″ long, how many and of what material would the Contractor figure on in making them?
26. What size are the main outside wall sills? The mid-sills? The front-porch sills?
27. What width cornice has the main part of the house? Is the dormer cornice of the same width?
28. What is the length of run of the upstairs stairs? It will require comparison of both floor plans and scaling to determine this.
29. How many flues are there? What size are they? Are they tile lined?
30. Does the brick foundation wall under the front porch extend back of the steps?
31. Of what material is the outside wall to the furnace room made? Is it of the same material above grade as below?
32. What does the small rectangle in the center of the fire-place on the Floor Plan indicate? Confirm your answer by study of the Fireplace Detail.
33. Does the fireplace have a damper? Cleanout? Ashdump?
34. Is it to be lined with fire brick?
35. Does the fireplace chimney extend out into the living room?
36. What keeps ashes falling through the ash dump from getting under the house?
37. If the weight of the fireplace should cause it to settle would the outer hearth settle with it?
38. Of what material is the fireplace mantle shelf?
39. Why was it necessary for the architect to place a pier under the wall between the bath room and the back porch?
40. Are there any two way light switches?
41. Are there any gas lights provided?
42. Are any of the lights to be drop lights?
43. Where is the switch to the basement light located?
44. Where is the store room light controlled from?
45. What provision is made in some of the rooms for connecting up fans, special electric lights, etc?
46. What does the little square with a figure 4 in it located at the exact center of the living room indicate?
47. What does the Character S^2III near the door to the upstairs indicate?
48. What rooms have no heat registers?
49. Where is the furnace cold air to come in at?
50. How is the servant room to be warmed?
51. What size sewer pipe serves the house? Water main?
52. What size pipe furnishes water to the kitchen sink? What size is the drain pipe?
53. How many cocks are provided for yard hose service?
54. Is a hot water piping system to be provided?

XIII. STUDY OF THE BENCH GRINDER

In the study of a set of drawings consisting of an assembly and details, it is always best to begin one's study of them by a study of the assembly drawing first. Doing this gives one an idea of the whole machine—or whatever the object is—so that the details are more readily understood.

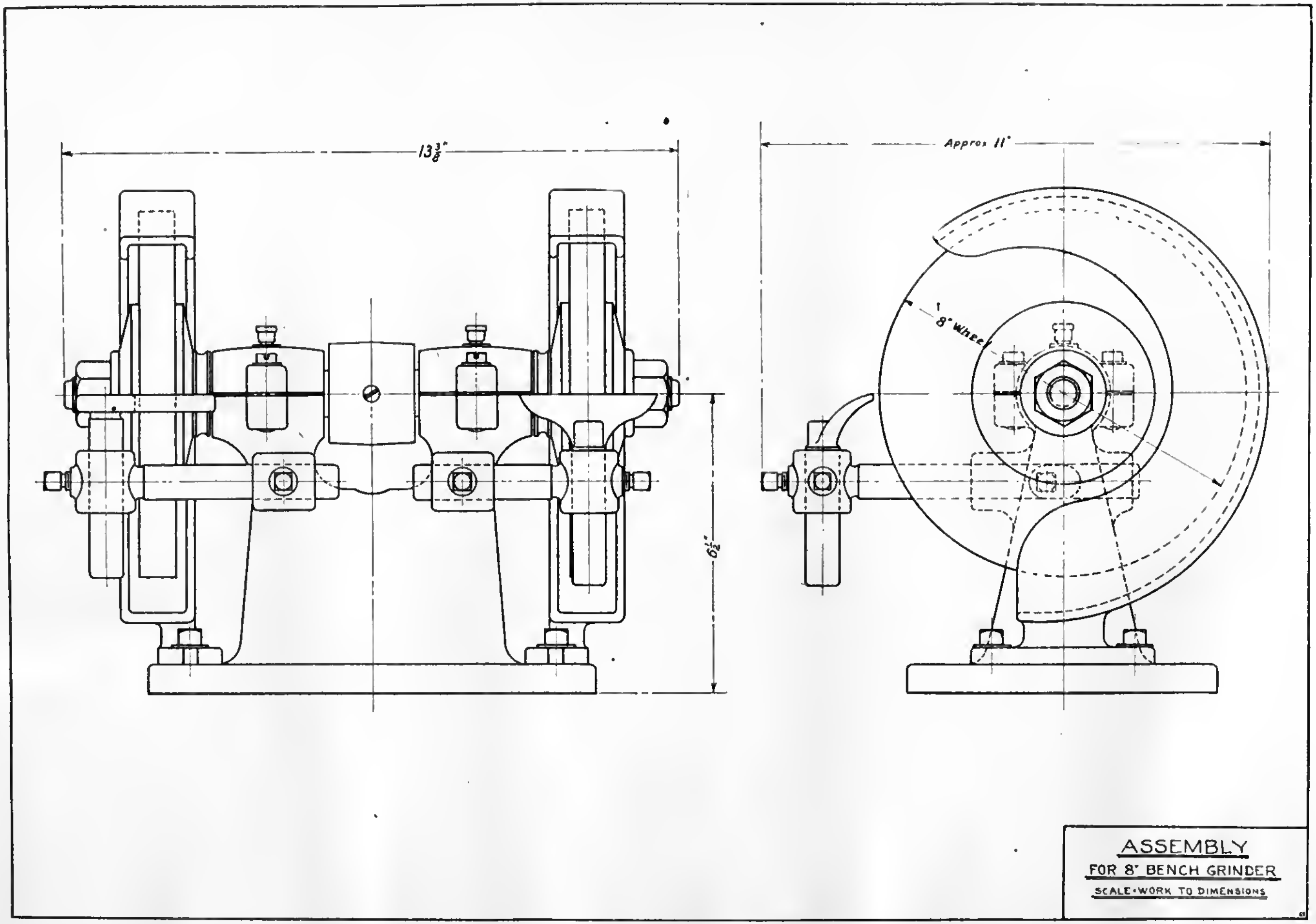
The student will therefore begin his study of the drawings of the Bench Grinder by a study of the assembly first—Plate XIX. Here he finds all the parts of the machine assembled, each piece occupying its intended place. He will at once recognize that it is a common two wheeled type of bench grinder intended to be mounted on a bench or pedestal. As he studies it over he will soon realize that there is a little difference between the two ends and investigation shows that different types of rests are used for the different wheels. Perhaps the machine is made with either type of rest and the draftsman has made one assembly show both arrangements. This matter can be settled when the student gets to studying over the detail drawings, because the detail drawings will show the number of each part required for each machine.

Some details ordinarily on detail drawings are omitted on assembly drawings. On this drawing the student will note that there are no dimension lines except three or four over all dimensions to give an idea of the size of the grinder. Draftsmen will somesometimes put on an assembly drawing dimensions which might be of use to the assembling machinist. Evidently this draftsman considered that the overall dimensions all that were necessary on the bench grinder. There are no marks indicating finish nor notes indicating the kind of materials. Very few hidden edges are indicated. Some necessary parts not among the detail drawings such as stock cap screws, set screws, oil cups, etc., are shown in the assembly only.

It will be noticed that many details of construction cannot be interpreted from the assembly drawing because the draftsman has had to leave out these details to prevent confusion of lines. For instance;—there is almost no information given regarding the spindle on which the grinding wheels are mounted.

The student will do well now to glance over the detail drawings, Plates XX to XXIX, getting a general idea of the individual pieces of the machine. He will doubtless turn back occasionally to the assembly in surprise at the many things which had escaped him in the maze of lines making up the assembly drawing. He will also go back to the assembly to locate the place of a part on the machine as a whole.

After a cursory looking over of the detail drawings the student should go over the detail drawings one by



13 3/8"
Approx 11"
8" Wheel
6 1/2"
ASSEMBLY
FOR 8" BENCH GRINDER
SCALE·WORK TO DIMENSIONS

Plate XIX

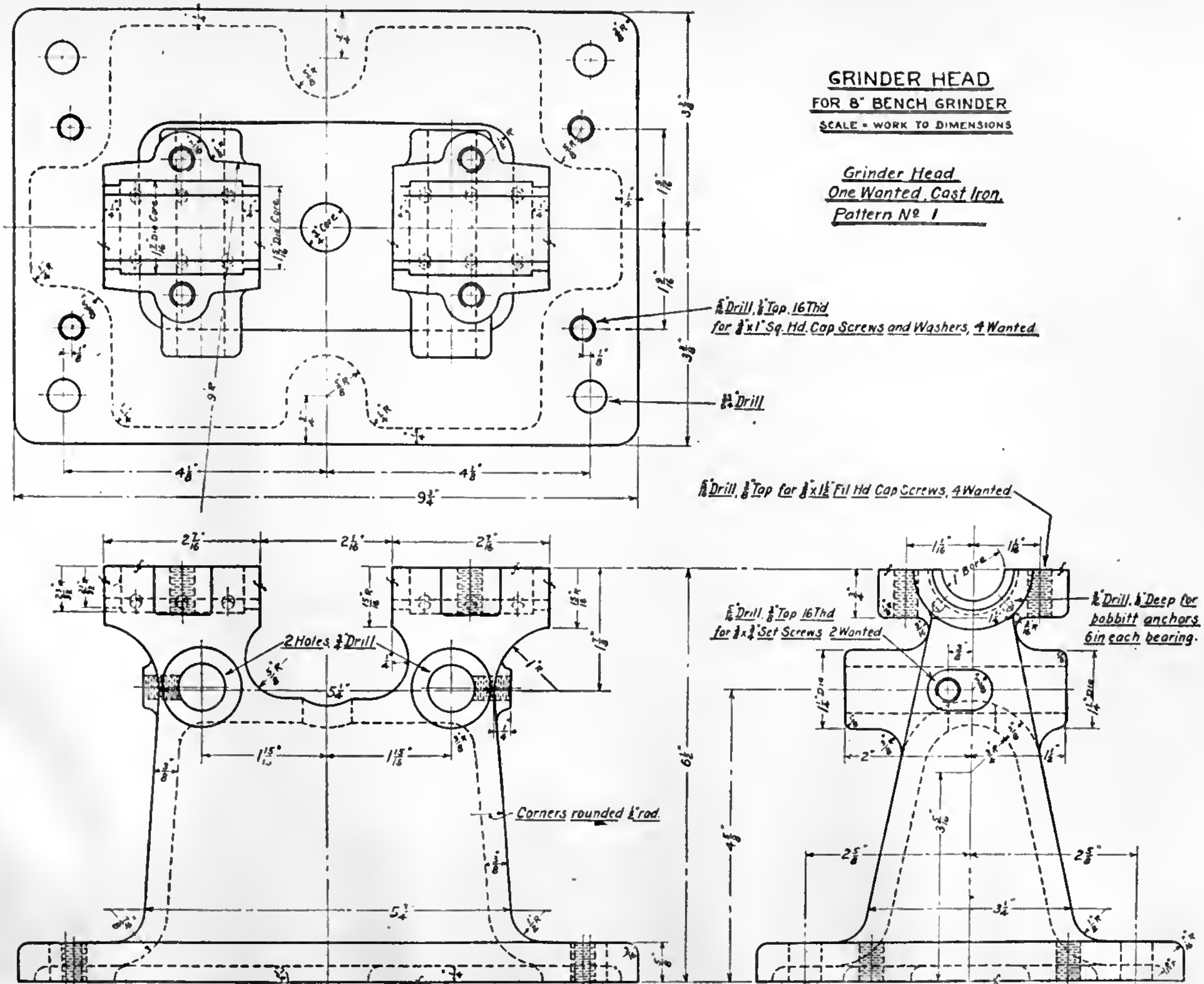
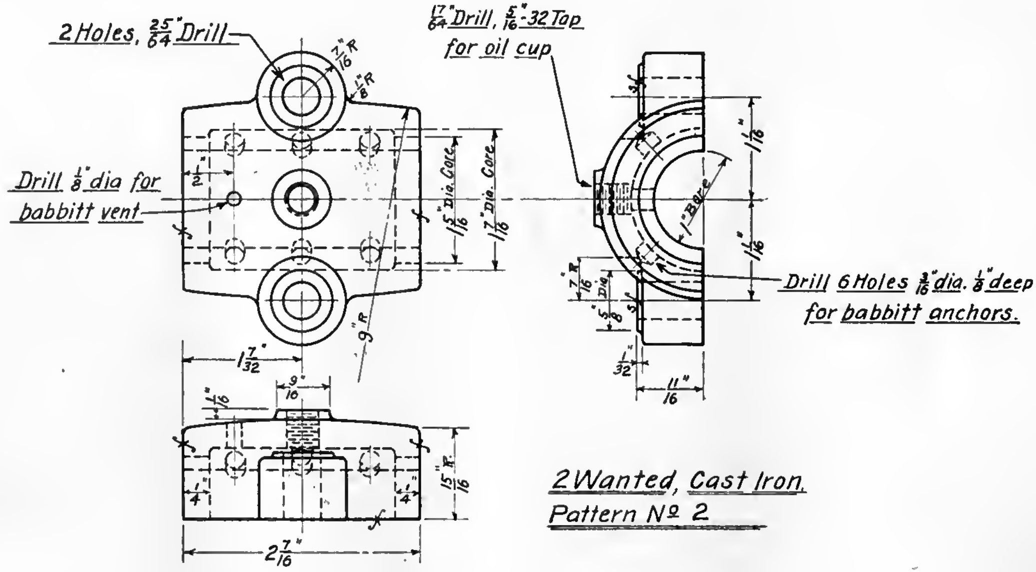

GRINDER HEAD
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS
Grinder Head
One Wanted, Cast Iron.
Pattern Nº 1
Drill
2 Holes Drill
Corners rounded rad.
bobbitt anchors
6 in each bearing.
Bore

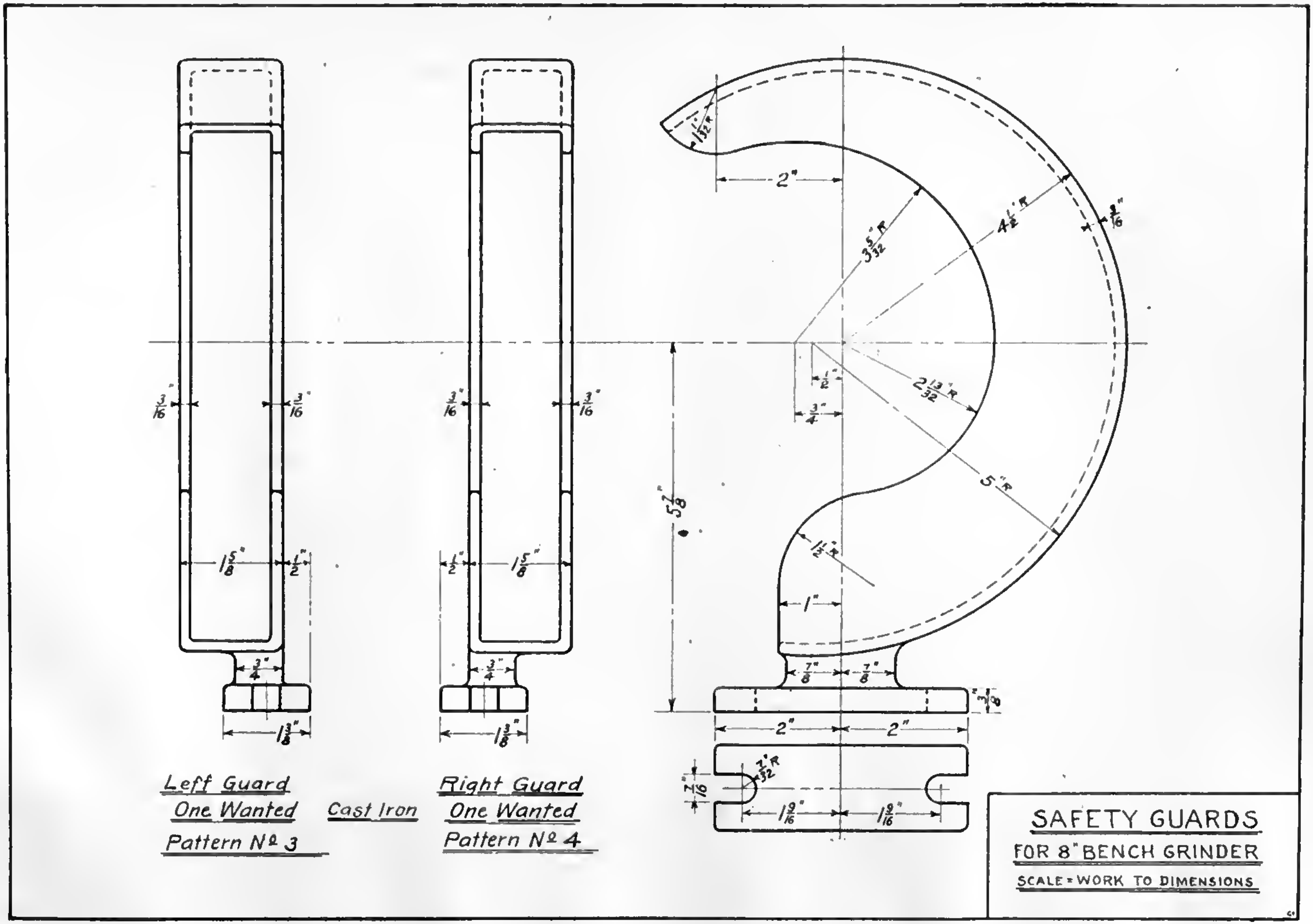
Plate XX



HEAD CAP

FOR 8" BENCH GRINDER

SCALE = WORK TO DIMENSIONS



Left Guard
One Wanted
Pattern Nº 3
Cast Iron
Right Guard
One Wanted
Pattern Nº 4
SAFETY GUARDS
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS

one for a thorough detailed study and in this we will try to lead and aid. It is usually best to begin with the larger details first as they are likely to influence other details, so we give our first detailed study to the Grinder Head, Plate XX.

We see the draftsman has made use of a three view drawing—top view, front view, and side view. The rectangular boundary line of the top view is readily recognized, after a confirmatory glance at the other two views, to show that the base of the grinder head is rectangular in shape. This is information the student may have assumed in the study of the assembly but was not necessarily so as without further information than that given in the assembly drawing the student would have been just as much justified in assuming that the base was elliptical, or oval.

Study of the front and side views show that the central portion of the grinder head is somewhat wedge shaped. A note on the front view calls attention to the fact that the corners are rounded off. The student will find this same information given by a radius dimension in the top projection.

The side view shows very clearly large projecting lugs on the back and front. The top and front views show that there are four of these lugs, two at each end. A note shows that these lugs are drilled with ¾″ holes. Reference to the assembly shows that these holes are for the Rest Brackets to go into.

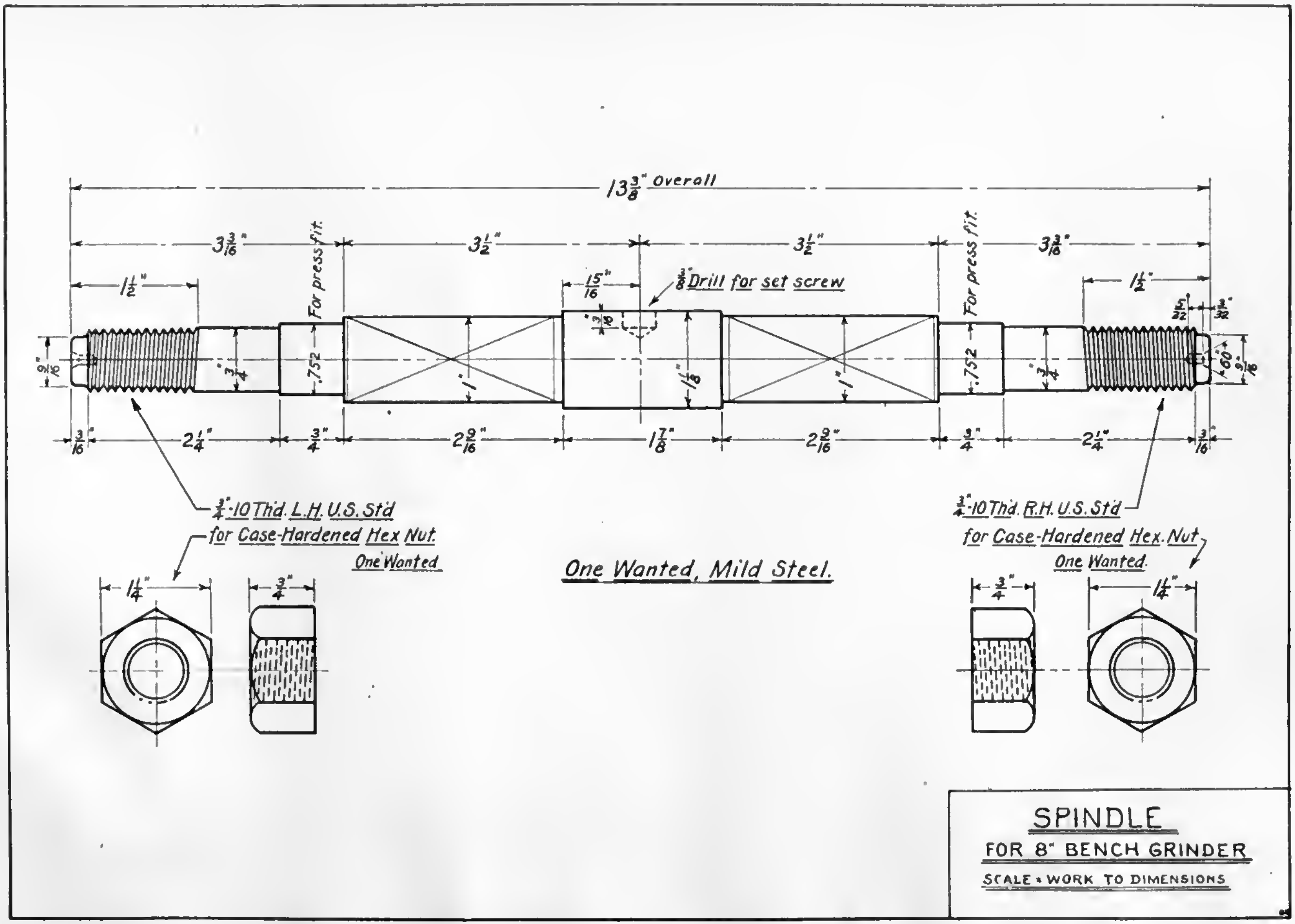
The upper part is clearly a double bearing. It is shown with babbitt bearings in place. The small finish marks (*f*) show that the top and ends of each of the bearings is to be finished.

The note in the upper right part of the plate gives the number of these grinder heads required for the machine and also of what material it is to be made.

The next drawing the student will direct his attention to is the Head Cap—Plate XXI. In most respects it is like the top of the Grinder Head.

Much of the details given by this drawing are seen to be a duplication of similar parts in the top of the Grinder Head. The babbitt bearing part is seen to be exactly a duplicate except for the oil hole drilled through the top and a babbitt vent as an aid in pouring the bearing. Screw threads and a note show that an oil cup is to be screwed into the oil hole. The holes for fastening the Cap onto the Head are not threaded as they were in the Grinder Head. A note states that each machine is to have two of these caps and that they are to be made of cast iron.

In the drawing Safety Guards—Plate XXII,—the student will note a quite common practice among draftsmen—that of combining similar parts so that



13 3/8" Overall
3 3/16"
3 1/2"
3 1/2"
3 3/16"
1 1/2"
1 1/2"
15/16"
3/8" Drill for set screw
For press fit.
For press fit.
.752
.752
3/4"
1"
1 1/8"
1"
3/4"
9/16"
9/16"
5/32
3/32
60°
3/16"
2 1/4"
3/4"
2 9/16"
1 7/8"
2 9/16"
3/4"
2 1/4"
3/16"
3/4"-10 Th'd. L.H. U.S. Std
for Case-Hardened Hex Nut
One Wanted
3/4"-10 Th'd. R.H. U.S. Std
for Case-Hardened Hex. Nut
One Wanted.
One Wanted, Mild Steel.
1 1/4"
3/4"
3/4"
1 1/4"
SPINDLE
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS

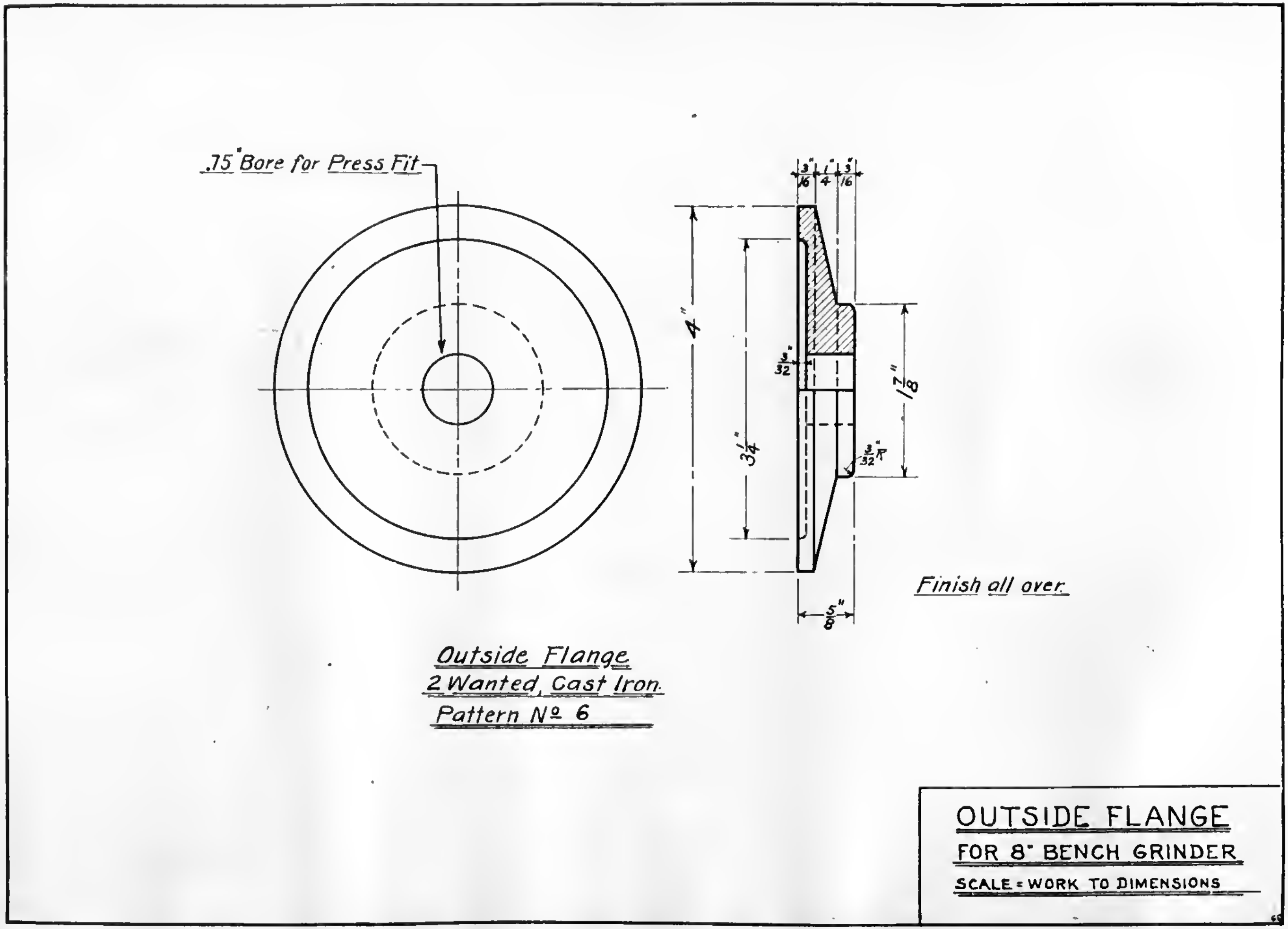
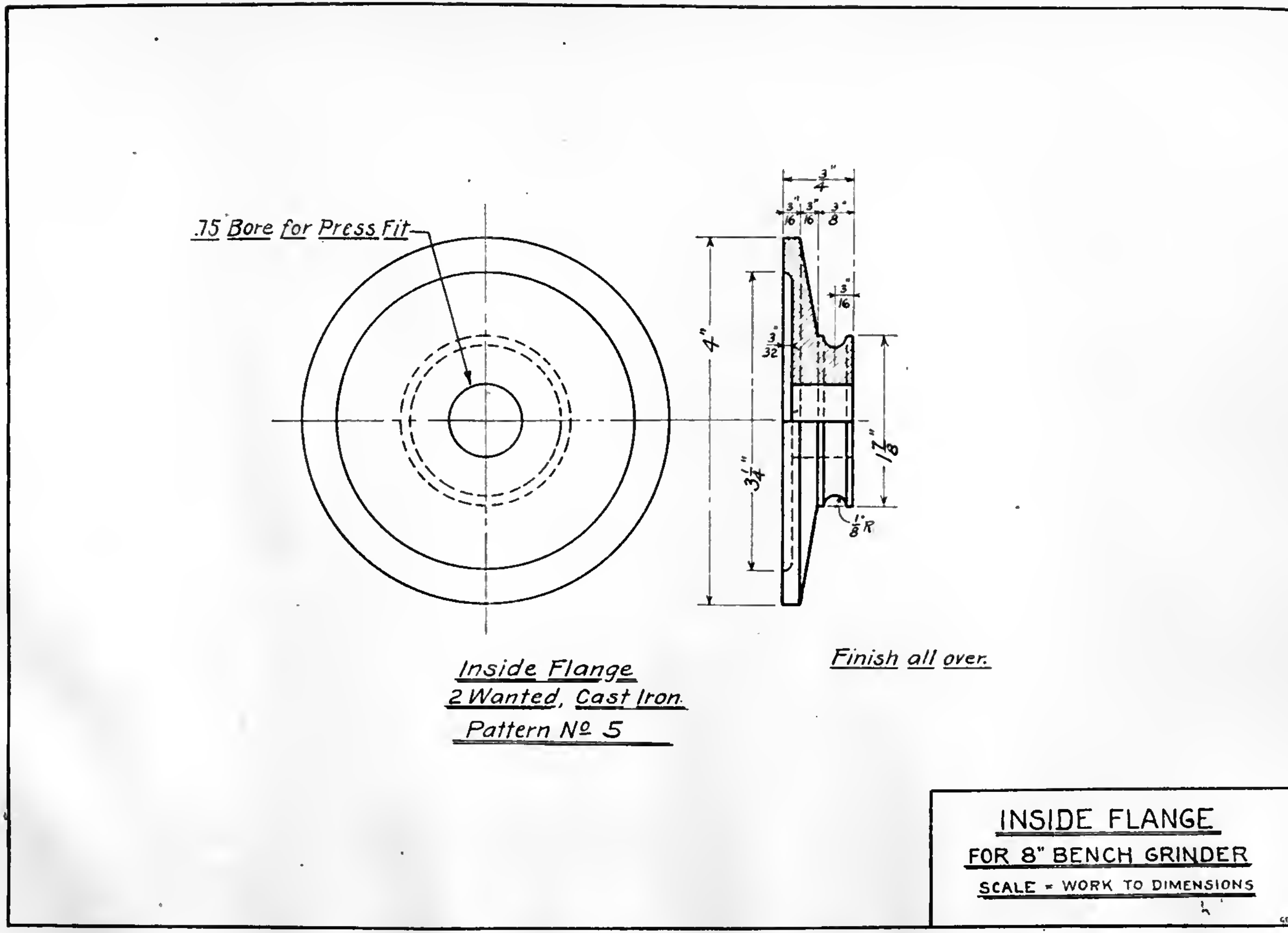

.75" Bore for Press Fit
3/16"
1/4"
3/16"
4"
3 1/4"
3/32"
1 7/8"
3/32" R
5/8"
Finish all over.
Outside Flange
2 Wanted, Cast Iron.
Pattern No. 6
OUTSIDE FLANGE
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS

Plate XXIV


.75 Bore for Press Fit
3/4"
3/16" 3/16" 3/8"
3/16"
3/32"
4"
3 1/4"
1 7/8"
1/8" R
Finish all over.
Inside Flange
2 Wanted, Cast Iron.
Pattern No 5
INSIDE FLANGE
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS

one view serves for two drawings. This is a drawing of two separate guards, one for the left and one for the right of the machine. The right guard is drawn with a front and right side view but only a front view of the left guard is shown. Evidently the side view of the right guard is to be interpreted as being the same for both guards. The draftsman has made use of an auxiliary view of the bottom omitting from the view all parts already sufficiently illustrated in the other views.

In the drawing of the Spindle—Plate XXIII—the draftsman has made use of a convention often used in machine drawings but not explained heretofore in this book. This is the use of the large crossing lines in the 2 9/16″ lengths of the spindle. Crossing lines thus used on a machine drawing indicate a bearing surface and serve to put the machinist on notice to be careful of the size and finish of the surfaces.

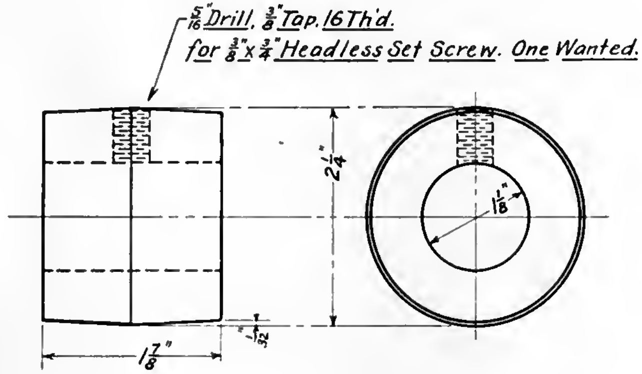
The student should note that there is a difference in the threading of the two ends. This will explain the reason for two drawings of the hexagonal nuts. The draftsman could have combined these similar to the drawing of the guards in the previous plate using these views, or he could have drawn but one drawing of two views drawing the hidden edge lines representing the threads horizontally and depending upon a note to explain that one was to be made with right hand threads and one with left hand threads. The draftsman evidently thought that the saving of these few lines hardly justified the risk of error involved.

The student will note the use of decimal fractions to insure extreme accuracy in those parts involving pressed fits.

In the drawings for the flanges, Plates XXIV and XXV, two view drawings are used. The student should note however that one view is rendered half in section as discussed in the latter part of Chapter VIII.

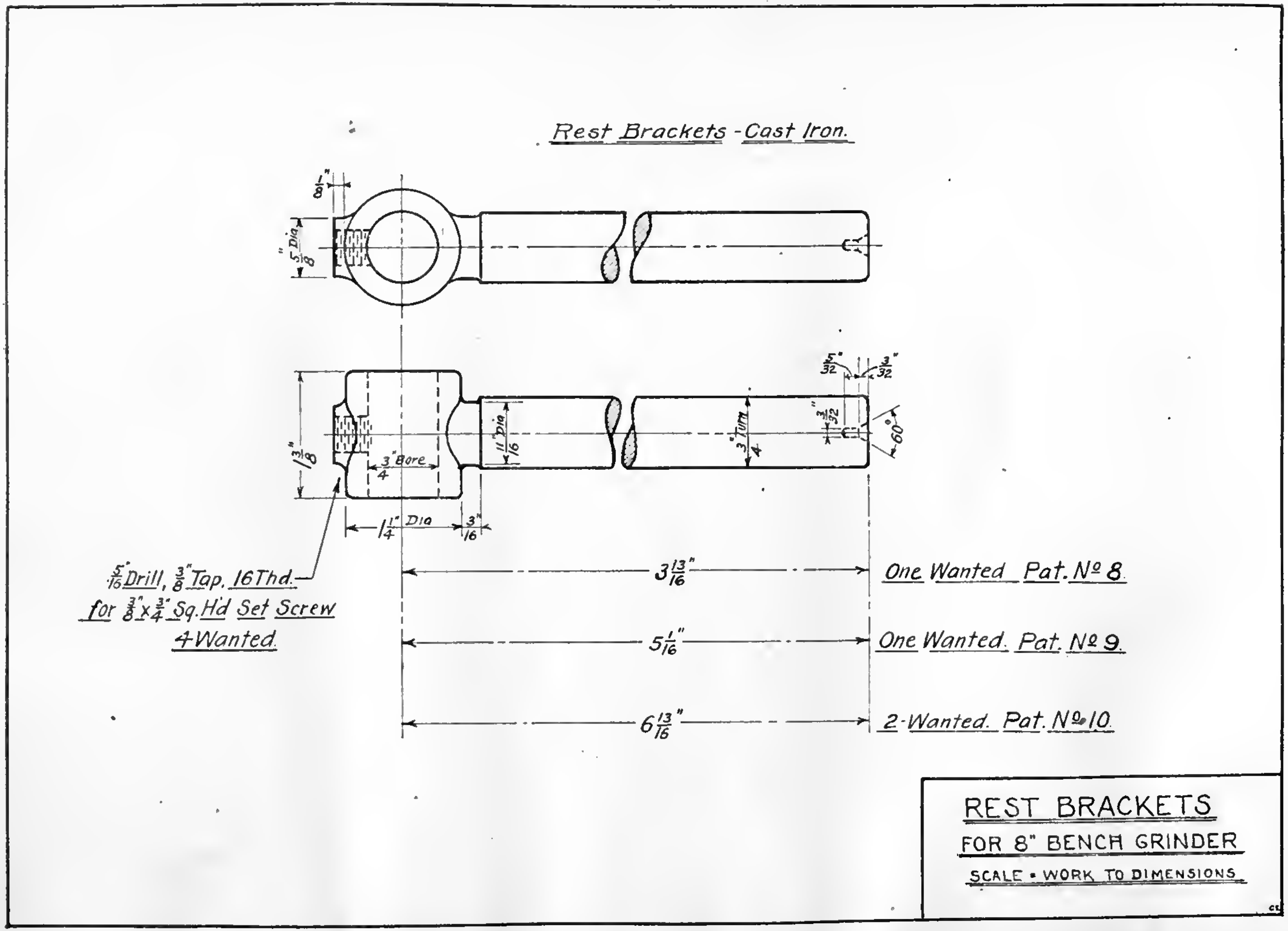
The Spindle Pulley, Plate XXVI, is readily recognized as a solid cast iron pulley, crowned in the center and intended to be held in place by a headless set screw.

In the drawing of the Rest Brackets, Plate XXVII, the student will note that the draftsman has made one drawing serve for three different length rest brackets by the simple expedient of dimensioning the length with these different dimension lines and placing a note stating the members wanted after each dimension. In order not to have his drawing out of scale for two of the dimensions he has resorted to a break. The break also helps to establish the fact that the shaft of the bracket rest is round though the word "turn" used



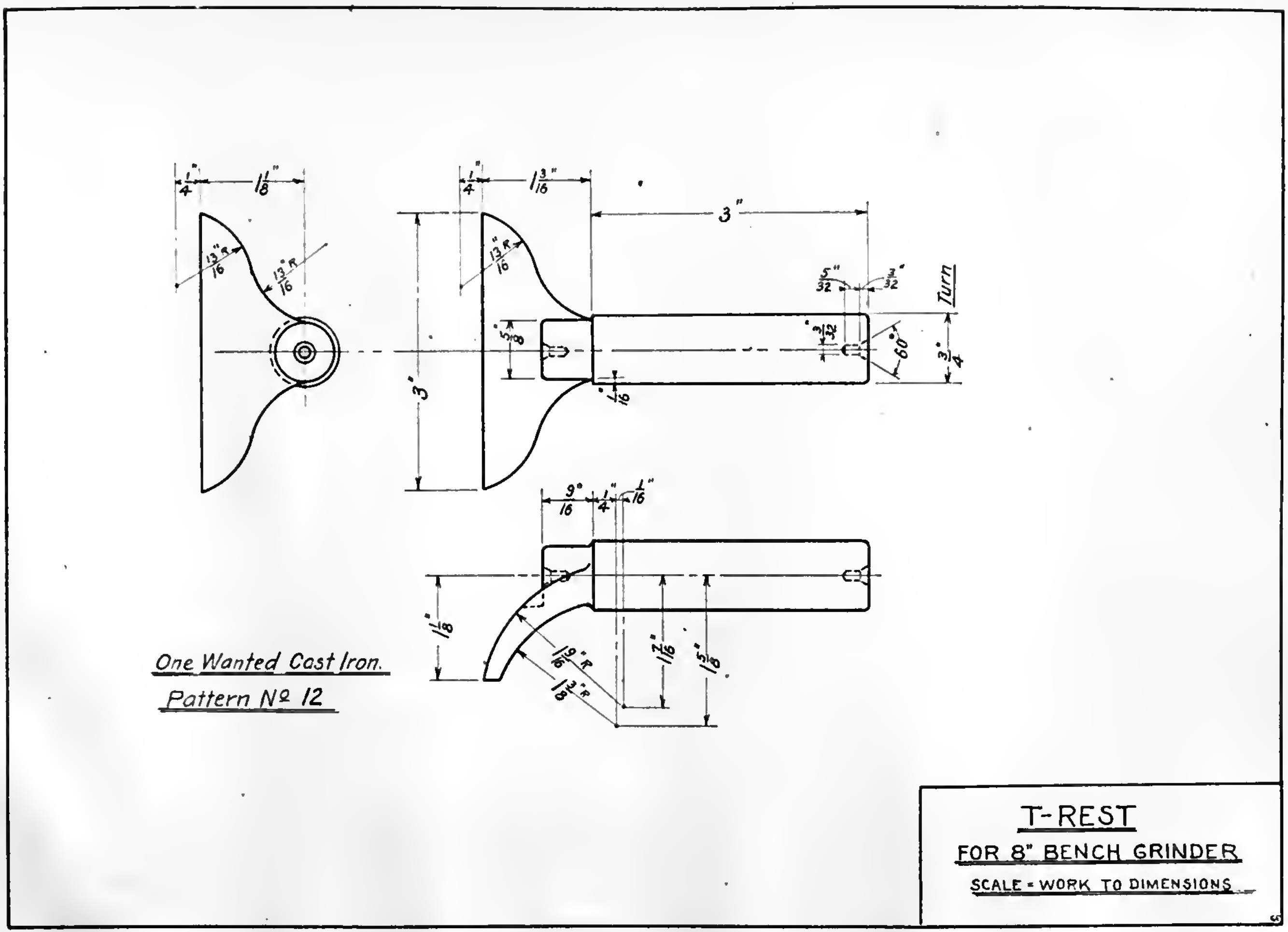
One Wanted, Cast Iron, Finish all over.
Pattern № 7

SPINDLE PULLEY
FOR 8" BENCH GRINDER
SCALE - WORK TO DIMENSIONS



Rest Brackets - Cast Iron.
1/8"
5/8" Dia
3/4" Bore
1 3/8"
11/16" Dia
3/4" Turn
5/32"
3/32"
3/32"
60°
1 1/4" Dia
3/16"
5/16" Drill, 3/8" Tap. 16 Thd.
for 3/8" x 3/4" Sq. Hd Set Screw
4 Wanted.
3 13/16"
One Wanted Pat. No 8.
5 1/16"
One Wanted. Pat. No 9.
6 13/16"
2-Wanted. Pat. No 10.
REST BRACKETS
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS

Plate XXVII


One Wanted Cast Iron.
Pattern Nº 12
T-REST
FOR 8" BENCH GRINDER
SCALE = WORK TO DIMENSIONS
Turn
3"
60°

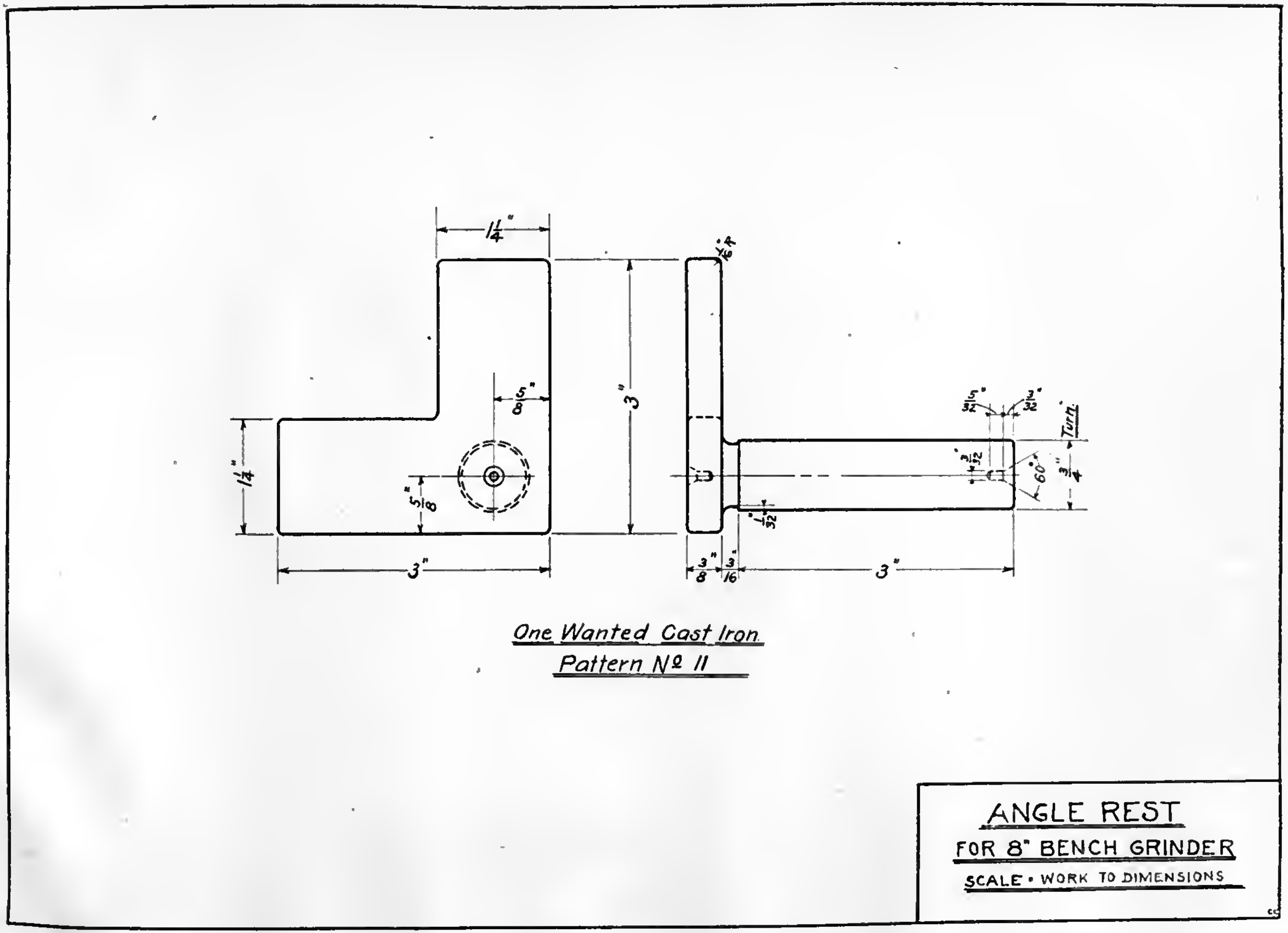
in connection with the ¾″ dimension also make this clear.

The drawings of the angle rest and T-rest, Plates XXIII and XXIX, are so simple as to involve no problems for the student to readily interpret them.

It will be well for the student to refer back and forth from plate to plate as he studies these drawings much as one might read a newspaper by reading headlines and the more interesting news items first then finally the intervening matter not at first given attention to.

QUESTIONS ON THE 8″ BENCH GRINDER.

1. What holds the babbitt bearings in place?
2. What does the dotted line weaving back and forth around the edges of the top view of Plate XX locate?
3. How thick are the side walls of the grinder head?
4. How large a surface will the base of the grinder cover?
5. How far apart are the centers of the holes for bolting the machine to the bench—both ways?
6. What diameter lag screws or bolts are to be used to fasten this machine to the bench?
7. The top view shows a ¾″ hole at the exact center. How is this hole to be made?
8. Is the bottom of the grinder head to be left rough or is it to be planed off?
9. Why are there four ⅜″ tapped holes in the bottom or flanged part of the grinder head?
10. Are bolts or cap screws to be used in fastening the caps on to the top of the grinder head?
11. What do each of the three concentric circles at the back of the top view of the head cap indicate?
12. How many threads per inch must be on the oil cups which go in the head caps?
13. How many finished surfaces on the head cap?
14. What do you figure to be the extreme width of the head caps, from back to front?
15. Is the height given?
16. Are the holes for the cap screws which hold the cap in place on the grinder head drilled or cored?
17. Are the surfaces under these cap screw heads to be machined?
18. How thick is the metal at the point where these cap screws go through?
19. Are the bottoms of the guards to be machined off or left rough?
20. Represent the two hex. nuts on Plate XXIII by one drawing as the draftsman used in representing the right and left guards, Plate XXII.



1 1/4"
3"
5/8"
1 1/4"
5/8"
3"
1/64 R
5/32"
3/32"
Turn
3/32
60°
3/4"
1/32"
3/8"
3/16"
3"
One Wanted Cast Iron
Pattern № 11
ANGLE REST
FOR 8" BENCH GRINDER
SCALE • WORK TO DIMENSIONS

21. Is the central $1\frac{7}{8}''$ length of the spindle round or square and how do you know?
22. Are square, V, or U. S. standard threads to be used and how many threads per inch?
23. Are the nuts to receive any special treatment that is not called for for the spindle?
24. Are the stone side faces of the flanges to be machine finished?
25. Are holes in the two flanges to be of the same size?
26. Is the spindle the same diameter where it supports outside and inside flanges?
27. How is the inside flange to fit on the spindle?
28. Why are two dotted circles on the face view of the inside flange and only one on the outside flange?
29. Why are there two circles used in representing the outside of the end of the spindle pulley?
30. How much crown is the pulley to have?
31. How is the pulley to be fastened to the spindle?
32. How many rest brackets are needed for the grinder?
33. How much of the rest brackets are to be machined off?
34. Of what material are the rest brackets to be made?
35. How many steel parts in this machine not including stock parts not detailed?
36. Make a bill of necessary accessories not detailed, such as grinder wheels, bolts, screws, etc., giving number needed, size and other information necessary for ordering.
37. What is the overall length and height of the machine?
38. What width belt would be needed to belt up the machine?
39. What size bolts to bolt it on to a 2" bench top? How many?
40. What scale are these drawings drawn at?
41. Which of the five kinds of drawings discussed in Chapter I, has the draftsman used in detailing the grinder?